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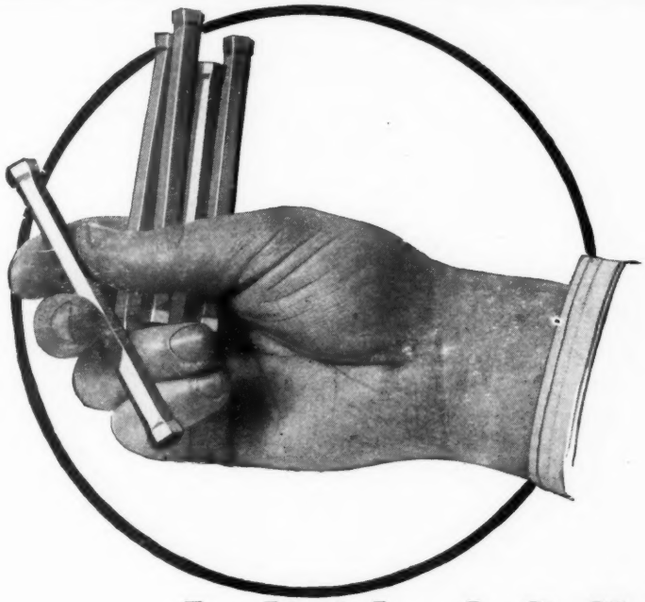

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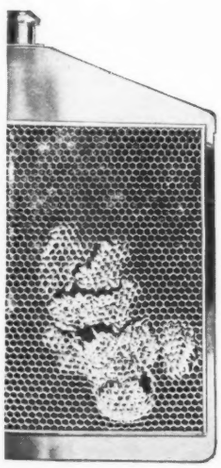

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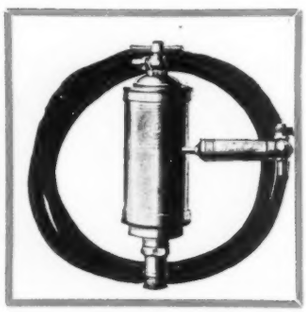

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AUTOMOTIVE INDUSTRIES
The AUTOMOBILE

VOL. XL NEW YORK—THURSDAY, JUNE 12, 1919—CHICAGO NO. 24

Some Immediate Problems

Engineering Comment on Pertinent Questions of Design

A NUMBER of engineers were asked by AUTOMOTIVE INDUSTRIES to write their opinions of certain features of design for automobile, truck and tractor control for the Engineering Issue. The comment was directed by questions which are printed with this article. The replies are an indication of the trend of opinion on these topics. You will find them interesting.

IF you could sit at luncheon with a dozen prominent engineers in the automotive industry and participate in the round-table discussion which would ensue, you could not fail to come away with many thoughts and perhaps a few inspirations. The status of the industry makes the views of engineers of the highest importance at this time.

In the following pages AUTOMOTIVE INDUSTRIES is presenting to you the approximate results of just such a conversation. The problems discussed are uppermost in the minds of automobile, truck and tractor manufacturers. We all realize that we are on the eve of many departures from what has been regarded as standard practice in the past. Changes, which on the surface appear radical, but which are really the fruits of development extending through several years, are about to be made. Never were the inventors, designers and engineers so busy in boldly carrying out principles which have been evolved in the laboratory, but which have not as yet been put into practice.

A War Benefit

It took the war to jog us out of a mechanical rut. The quality of workmanship in the automotive industry has gone up, due to the experience gained in the manufacture of airplanes, airplane engines and parts requiring closer degrees of inspection than anything we have ever had to do with in commercial work. The demands of the government inspectors, which appeared unreasonable in many instances, have acted as a spur toward more accurate manufacture.

The entire automotive industry is focused around the power plant. It is the development of the internal combustion engine in small units which has created this rapidly growing industry. Refinements which perfect the engine, increase the efficiency of the products of the industry and consequently are of the utmost importance to all engineers. It is not strange, therefore, that when engineers get together one of their prime considerations is the power plant. Many new things are developing in automotive engines.

The fuel situation has made it imperative that we must operate at higher thermal efficiency than the 15 to 20 per cent with which we have been content during the past decade. Some believe that the superinduction engine points the way toward higher thermal efficiency, but a reading of the views of other engineers shows that this opinion is by no means unanimous.

Is it possible to secure a much greater efficiency from an engine of definite size by ramming an excess charge into the combustion chamber so that the filling will not be 75 or 80 per cent, but, instead, will be possibly 105 or 110 per cent at the beginning of the stroke?

There are many possibilities in the future for piston developments. Nowhere else is there such a variety of opinion to be found. The question of the aluminum or

cast-iron piston, which we have been struggling with for 4 years, has not as yet been definitely answered. The questions which will be answered only by the future include whether or not the coming piston will be something along the lines of the hour-glass type or some other form of non-continuous wall, or whether it will be along the lines of the full cylindrical type. The Riccardo type of piston, which has both a guiding and a sealing element, has created an unusual amount of interest.

Aluminum pistons are being made by different makers for different purposes. Some are using aluminum because it is light, and these make their sections as light as is structurally possible, in order to cut down the reciprocating masses in the engine. Others use aluminum because it is an excellent conductor of heat, and these, in order to get the heat away from the center of the piston as rapidly as possible, use heavy section aluminum pistons, which weigh practically the same as those of cast iron.

How to get endurance and long life from the tractor engine has been a subject which is far from being exhausted. The engine builders are divided into two schools. One designs the engine to get all the power possible from a given displacement; the other designs the engine with restricted intake passages to automatically prevent the engine from being overworked.

Lubrication

Another important development in the tractor engine is the question of lubrication. A short time ago we were of the opinion that pressure lubrication was the only system for the tractor engine. That this opinion is by no means universal will be perceived from the discussion in these pages and conversation with various tractor engineers. The opportunity for allowing the oil to settle, produced by the splash system of lubrication, is important according to some, while others believe that the only way a tractor engine should be lubricated is by oil positively fed to all spots under high pressure.

Some of us who have watched performances on kerosene and have witnessed results which are far from satisfactory are wondering if it would not be better to discontinue the kerosene pretense and come out flat-footedly on a frankly gasoline basis. Some tractor engineers are thinking the same thing, but not all of them. Some believe that the few cents saved in fuel is more than made up by the amount spent in replacing lubricating oil and in repairing the damage due to the destruction of the oil film. The increased crankcase dilution due to the use of kerosene is believed by many to more than pay for the fuel price difference.

Trucks, passenger cars and tractors are all presenting transmission problems which are keeping engineers awake at night. In the passenger car field practically everyone is dissatisfied with the modern selective transmission, particularly as regards its noise on first and second speeds. The question is, can the present type of gearbox be improved so as to give the desired silence by superior design and workmanship, or is it necessary to go to some other type, which may perhaps be a radical departure from that in use.

There has been much criticism that the weight of rear axles, both of passenger cars and trucks, is too great. It has been often asked by engineers if it is not possible to materially reduce the axle weight by superior design. Little change has been made in the axle in recent years and the impression prevails that this point has not been fully taken care of. This is a big field for useful discussion.

Braking System

In no other matter is the opinion of engineers so unanimous as it is in regard to brakes. There is not an engineer who does not say that, taken as a whole, the brakes on American cars and trucks are inadequate. You cannot drive any American-made car or truck from Philadelphia to Pittsburgh over the Lincoln Highway and use the brakes like they should be used. The engine must be used as a brake in order to help out the inadequate system on the drum. This is not denied by any engineers with whom we have had an exchange of views. What are we going to do about it? This is a most important matter and one which should be taken care of immediately. Is the transmission brake the answer?

What do engineers think of the transmission brake as a hand brake possibility, thereby removing the linkage from the rear axle and also providing an independent drum not subject to the heat generated by the application of the foot brake? This, of course, gives a brake which would perhaps be more satisfactory to continuous hill work, but objections are advanced in the way of chatter, of excessive strains on the universals, and, where metal to metal brakes are used, of the extreme noisiness.

The Engineers' Forum

These problems, and others, are of such importance that the time has come for us to lay our cards on the table and throw the suggestions, which we all have, into the common melting pot, to evolve the answer. These problems are not going to be solved by any one individual or by any firm. The industry, as a whole, is going to be advanced as soon as they are solved and American-made products are going to increase their reputation throughout the world at a rate governed by the manner in which we handle these vital questions which now confront us. AUTOMOTIVE INDUSTRIES maintains an open forum in its pages and engineers are invited to discuss pertinent problems through its columns. In the following pages are given some of the opinions of leading engineers on the matters outlined in the foregoing.

As to the Automobile and Truck

By D. McCall White

I believe there is much to be said for superinduction for the purpose of ramming an excess charge into the combustion chamber, thereby increasing the volumetric efficiency, etc. This will, however, have to be accomplished in quite a different manner than in the devices I have seen. There are instances where crankcase compression has been used for this purpose and this appears to me to be quite an ideal way of doing the job, except for the fact that the entrance and exit of the air causes a considerable shuddering noise, which is very objectionable. Where supercharging is used, the means taken for injecting this charge into the cylinder must be such as to accomplish its purpose without objectionable noise.

On the matter of the future of piston development the hour-glass is a type of piston which I developed in England and which was in a measure successful. The only unfortunate thing about this is that, in view of the fact that reciprocating gases must be as light as possible, the pistons must be made short. In designing the hour-glass

THE QUESTIONS

THE views of representative engineers given on these pages are in answer to the following definite questions:

Passenger Car and Truck Questions

1—Do you believe in superinduction charges for the purpose of ramming an excess charge in the combustion chamber, thereby increasing the volumetric efficiency and consequently mean effective pressure?

2—What do you think of the future of piston development? Is it coming along the lines of the hour-glass type of pistons or some form of non-continuous wall, or do you believe that the full cylindrical type will prevail?

3—What do you think of the heavy type of aluminum piston as a possibility; also. what do you believe of the die cast aluminum pistons, perhaps used in certain such types as the Riccardo with a guiding element and a sealing element?

4—Do you believe there is any chance for a radical change in transmissions, getting away from the noisy performance on second and first speeds? What do you believe will be done to combat this noise in ordinary transmissions?

5—Do you think that rear axles are too heavy for the power transmitted? Will it be possible by superior design to greatly improve the rear axles?

6—What do you think of the transmission brake as a hand brake possibility, thereby removing the linkage from the rear axle, and also providing an independent drum not subject to the heat generated by the application of the foot brake; also, giving a brake which would be a true emergency brake and useful for continuous hill work?

Tractor Questions

1—What do you think of governing tractor engine performance by restricted intake passages.

2—What do you think of the splash vs. pressure lubricating question for tractor engines?

3—Do you think it would be better to sell tractors on a frankly gasoline instead of kerosene basis?

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type, one is apt to cut out too much surface. There is no doubt that the hour-glass type is a very stiff piston, but I believe that the full cylindrical type of piston will eventually prevail, because it has a maximum amount of surface, which is the best preventive against condensation getting past the piston walls and down into the crankcase. Likewise, it also forms the best possible seal to prevent the oil from passing upward into the combustion chamber.

Aluminum pistons I do not regard as a possibility under present circumstances, owing to the great amount of change in shape due to temperature. It may be possible to design a piston having a light cast-iron shell, with an aluminum head to carry away the heat, and this probably would be a good deal better than a complete aluminum piston.

Transmission Brakes

I believe there is a radical change coming in transmissions. This change will take the form of the epicyclic gear, electric transmission, chain transmission, or some other type differing from the designs in use. Likewise, in rear axles a change is coming. As they are designed at present, they are entirely too heavy for the power transmitted. By careful and scientific design I am certain that the rear axle can be greatly improved.

Transmission brakes have many things in their favor, and, likewise, against them. I have had a good many years' experience with transmission brakes, not only as a service proposition, but also as emergency brakes. In its favor it may be said that it has a great deal of power. However, the velocity of the drum itself is very great and rapid wear on the asbestos lining is sure to take place. If cast iron is used, there is sure to be much noise. Brake chatter is also very prevalent with the transmission brake, but there is no doubt that all of these things can be overcome by careful design and the matter is well worth careful investigation.—D. McCall White, Former Vice-President Cadillac Motor Car Co.

By E. Planche

It is, in my opinion, of paramount importance to completely fill the cylinders with the best explosive mixture during the complete range of speeds of the motor, especially since the general use of the heavy gasolines which have been furnished to the public in the last few years. This question has had my careful attention during the last 6 years and all motors I have designed during that period have had a specially designed inlet pipe, of conical shape, inside the cylinder block, thereby increasing the speed of the gases. I have also brought the carbureter as

(*Continued on page* 1356)

A New Method of Determining Rate of Flame Propagation

Originated by Dr. Donald MacKenzie of the Bureau of Standards and Successfully Applied to a Single-Cylinder Liberty Engine

By P. M. Heldt

ONE of the most interesting questions connected with the internal-combustion engine is that regarding the rate at which the flame or explosive wave is propagated from the point of ignition to the more remote parts of the combustion chamber. The term "rate of flame propagation" has been much used, especially in glib talks on the efficiency of different types of ignition apparatus, but it must be admitted that our knowledge on the subject so far has been exceedingly limited. It is true that a number of experiments have been made, but in practically every instance the explosion took place in a closed vessel, so that the effects of turbulence of the mixture and change in volume of the chamber were not brought out.

Just now the question of flame propagation is of peculiar interest, because of its bearing on the subject of knocking in engines. Various theories as to the causes of knocking have been advanced, and it has been impossible to check them because of imperfect knowledge of exactly what occurs in a cylinder after the spark has passed at the plug.

Principle of New Method

Dr. Donald MacKenzie of the Bureau of Standards has evolved a new method of measuring the rate of flame propagation which is based on the principle that when the atmosphere surrounding a pair of spark terminals is flame, the electrical pressure required to break down the resistance of the gap is reduced. Thus, if there is an extra, inactive spark plug in the combustion chamber, the spark terminals of which are subjected to a voltage which is just short of creating a spark when the gap is under the normal compression pressure, then as soon as the flame reaches the gap ionization takes place; that is, there is a transfer of electricity from one electrode to the other. By passing both the sparking current and the discharge across the terminals of the inactive spark plug through the coil of an oscillograph, wave diagrams of both of these discharges can be recorded on the same sensitive plate. If, in addition, the sine curve of an alternating current from service mains of known periodicity is recorded on the plate, an accurate time scale is automatically obtained, and the time it took for the flame to travel from the working to the inactive plug can be readily measured.

Experiments are being conducted on a single-cylinder Liberty engine which is set up in a temporary structure at the Bureau of Standards. The work is being done by Dr. MacKenzie and R. K. Honaman, who in a recent paper before the American Physical Society at Washington gave a description of the set-up employed and an outline of their plans.

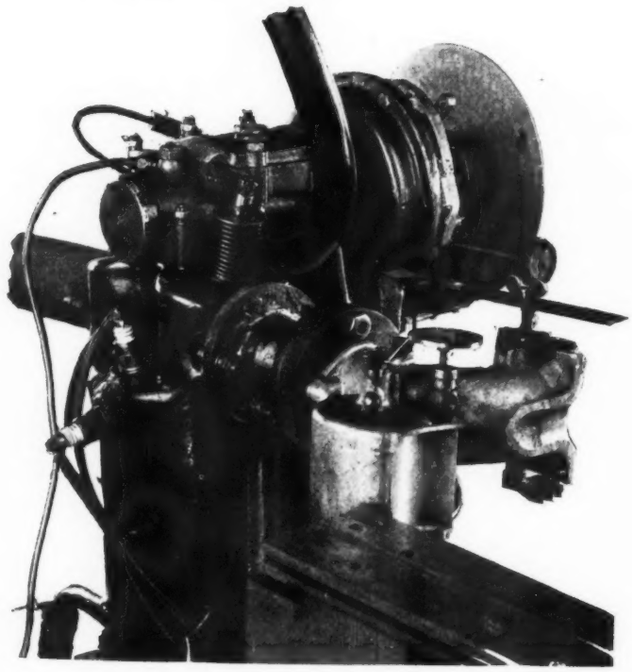


Fig. 1—Single-cylinder Liberty engine used in experiments to determine rate of flame propagation

A photograph of the Liberty single-cylinder engine used in the experiments is reproduced (Fig. 1). As is well known, the standard Liberty cylinder has two spark plug bosses, both in the cylinder head, in the corners between the valve pockets. In this particular cylinder a third spark plug boss has been provided at the side of the combustion chamber. The spark plug in the last-mentioned boss is used for ignition, while the two other spark plugs are used for observations on flame propagation.

In Fig. 2 is shown a diagram of the electrical connections. To obtain the high voltage required at the terminals of the inactive spark plugs, use is made of a transformer by means of which alternating current from service mains is stepped up from 100 to 5000 volts. Both terminals of the secondary of this transformer are connected to Kenetron tubes, or vacuum tube valves. For the benefit of those not familiar with this type of electrical device, it may be explained that a Kenetron valve is a vacuum tube containing two electrodes, one in the form of a disc and the other in the form of a coiled filament, which can be brought to incandescence by current from a low-voltage battery. The battery circuit is closed through the filament and the complete device is then included in the alternating-current circuit, one alternating lead being connected to the filament electrode and the other to the disc electrode. During that part of the cycle when the hot electrode is negative, electrons, or

small particles of negative electricity, are projected from it toward the cold, positive electrode, these electrons forming current carriers. There is no corresponding action during the other half of the cycle, when the hot electrode is positive. Hence, only impulses in one direction pass through the vacuum tube.

The unidirectional high electromotive force obtained from the transformer, through the vacuum tube valves, is used to charge two condensers, C^1 and C^2, through high resistances R^1 and R^2. Toward the end of the compression stroke, a moment before the spark passes at spark plug No. 1, condensers C^1 and C^2 are electrically connected to the central terminals of spark plugs Nos. 2 and 3 respectively, by means of a contact disk which is mounted on the overhead camshaft (and which can be seen in Fig. 1). Thus, when the spark passes at plug No. 1, plugs Nos. 2 and 3 are subject to a static pressure of about 3000 volts. As soon as the flame of the explosion reaches the gap of spark plug No. 2 ionization takes place and the condenser connected to this plug will discharge. By tracing out the connections it will be seen that the discharge current has to pass through the oscillograph vibrator. The same thing is repeated a moment later at plug No. 3.

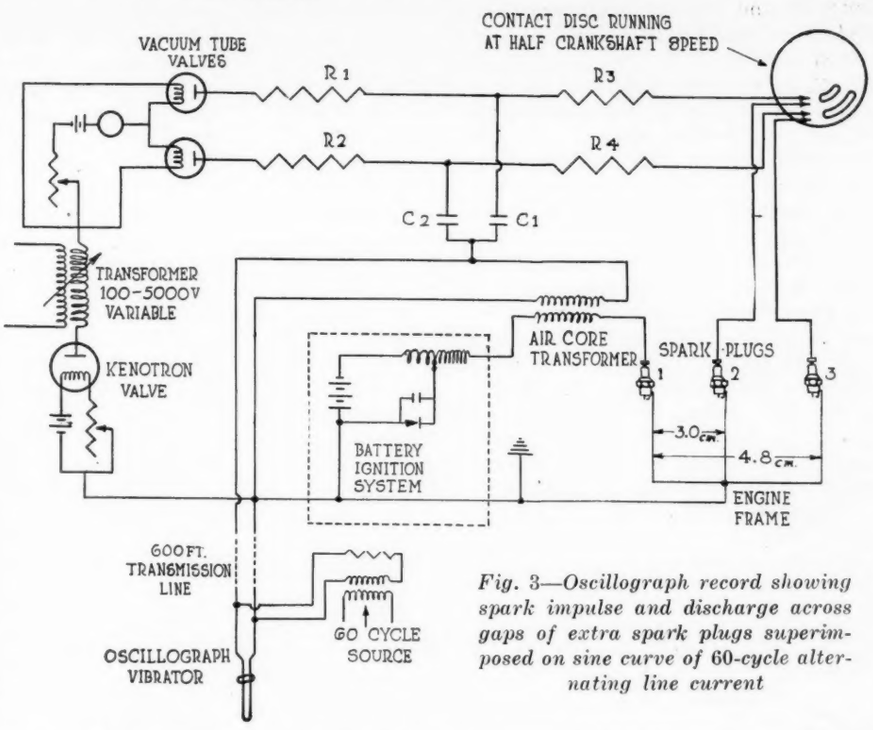


Fig. 3—Oscillograph record showing spark impulse and discharge across gaps of extra spark plugs superimposed on sine curve of 60-cycle alternating line current

The regular battery ignition system is used for igniting the single-cylinder engine, the secondary terminal of the ignition coil being connected to spark plug No. 1, at the side of the combustion chamber, through the primary of an air core transformer. The secondary winding of this air core transformer is connected in circuit with the oscillograph. This instrument is located in another building, and connection to it is made through a 600-ft. transmission line. A 60-cycle alternating current is also sent through the oscillograph, and this traces a sine curve on the oscillograph plate, which serves to determine the time scale.

Character of Oscillographic Record

The effect obtained on the oscillograph plate, therefore, is as follows: A continuous sine wave is traced by the current from the 60-cycle source. When the spark occurs at plug No. 1, an impulse is induced in the secondary of the air core transformer, and this produces a corresponding impulse of the oscillograph vibrator, which is superimposed upon the sine curve. A moment later, as the explosive wave reaches the gap of spark plug No. 2, condenser C^1 discharges through this plug, and since the discharge passes through the oscillograph, the record of this sudden current impulse is also superimposed upon the sine curve. The same phenomenon is repeated a moment later when the explosive wave reaches the gap of spark plug No. 3.

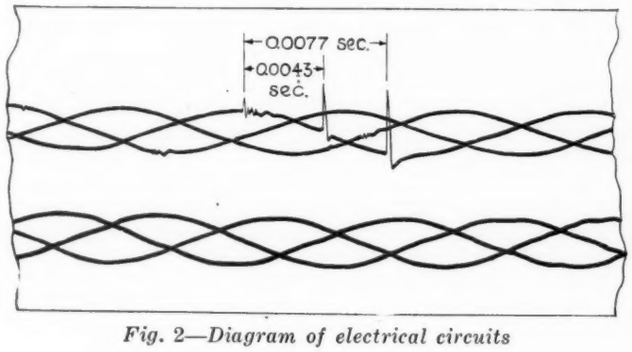


Fig. 2—Diagram of electrical circuits

Some of the details of the electrical circuit require further explanation. There might be a question as to the need of the contact disk at the end of the camshaft, as the open circuit at the spark plug should prevent a discharge of the condenser taking place. It was found that in order to make the apparatus most effective, the voltage applied to the spark plugs must be not far short of that required to produce a disruptive discharge under full compression. Such a pressure on the spark plugs, however, would cause a spark to pass at the beginning of the compression stroke, when there is little compression in the cylinders. Hence, the contact disk is needed.

An expedient resorted to in order to obtain as sharp a signal as possible upon the arrival of the explosive wave at the inactive spark plug consists in making the values of the resistances R^1 and R^2 from 40 to 50 times as large as those of resistances R^3 and R^4. This minimizes the current from the vacuum tube valve flowing through the spark plug circuit, while, on the other hand, the low value of resistances R^3 and R^4 allows a rapid discharge of the condensers through the spark plugs. Also, the charging of the condensers from the transformer through the valves is distributed over a comparatively long time. The actual values of the resistances are 15,000 ohms for R^3 and R^4 and 600,000 ohms for R^1 and R^2. The two condensers C^1 and C^2, which have a capacity of 0.0034 microfarad each, are charged to a potential of about 3000 volts. This results in an initial discharge current of about 0.1 ampere and gives a deflection of the oscillograph vibrator of 20 mm. (0.8 in.). On the other hand, the maximum rate at which charge enters the condensers is only about one-twentieth of this.

It will be noted from Fig. 3 that three Kenetron valves are used, one on one side of the transformer secondary and the other two on the opposite side, in parallel. Valves B^1 and B^2 are required only because if resist-

ances R^1 and R^2 were both directly connected to the secondary of the transformer, current from condenser C^2 would discharge through R^1, R^2 and R^3 into spark plug No. 2, so that the potential of C^2 would be greatly reduced before the flame reached plug No. 3, and no discharge would take place across the gap of this plug. Valves B^1 and B^2 allow charging to take place freely, but prevent an interaction of the two discharging circuits.

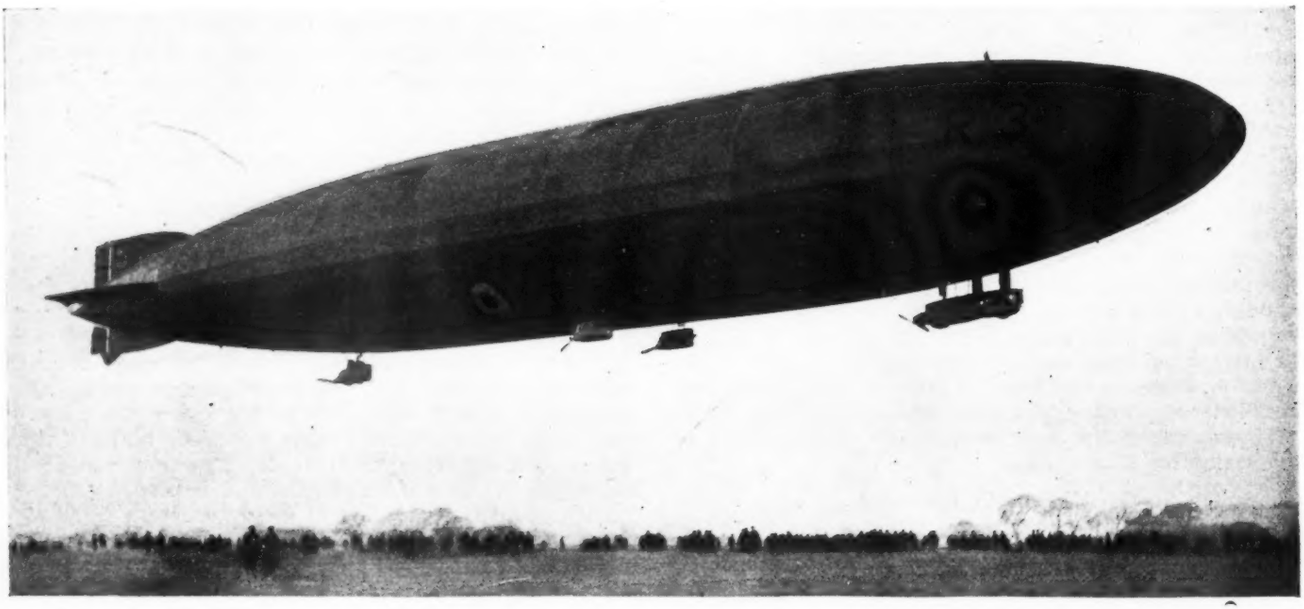
A somewhat puzzling feature of Fig. 3 is that there are 3 sine waves on the slide. The reason for this is that the shutter of the oscillograph was held open for three successive revolutions of the drum. The equal phase relation of the three curves was obtained by properly adjusting the speed of the drum.

It will be noted that the ignition spark is indicated on the oscillograph by a number of successive pulsations. This curve, of course, is no direct record of the spark, but a curve of its first derivative, as it is the secondary current from the air core transformer that produces the record on the plate.

As noted in the diagram, Fig. 2, the distance between spark plugs Nos. 1 and 2 is 3 cm., and the distance between Nos. 1 and 3, 4.8 cm. Fig. 3 shows that under the particular conditions of operation under which this oscillogram was obtained it took the flame 0.0043 second to travel the first-mentioned distance, and 0.0077 second to travel from plug 1 to plug 3. Measurements taken on different films have shown that the rate of flame propagation varies greatly with the conditions under which the engine is operated. Some of the factors affecting it are the richness of the mixture, the compression ratio, the heat content of the ignition spark, and the degree of turbulence within the combustion chamber. It was found in all cases that the velocity of flame propagation increased with the distance from the ignition plug. For the first 3 cm. (the distance between the ignition and the nearest inactive plug) the values varied between 5 and 25 meters per second, and for the first 12 cm. (the distance between plugs 1 and 3) it varied all the way from 15 and 60 meters per second.

The practicability of the method having thus been established, it is planned to carry out a complete series of tests to determine the effect upon the rate of flame propagation of all the different factors, such as mixture, composition, degree of compression, spark advance, intensity of ignition spark, grade of fuel used, etc.

Measurements and Tests of the British R-34



RECENT cable messages tell of an unusual test sustained by the British airship which is expected to start a trip across the Atlantic in the near future. This test flight was not planned, but was the result of the dirigible becoming lost in a fog and being in the air 21 hours and returning to her hangar under her own power.

"R-34 was built for the British Admiralty at the Airship Works of Wm. Beardmore & Co., Ltd., Inchinnan, Renfrewshire, Scotland, and the photo shows the vessel in the air prior to carrying out a successful trial flight on March 15. The ship is about 650 ft. long by 80 ft. in diameter, and it has a capacity of more than 2,000,000 cubic feet, with a useful lift of over 30 tons. She is fitted with Sunbeam engines and capable of attaining a speed of about 70 miles per hour. The preliminary trial extended over a period of 4½ hours under favorable weather conditions and the ship flew at various altitudes up to 2,000 feet. The ship's complement numbered about 30, including several technical members of the Beardmore staff. "R-34" is a great improvement over the other dirigibles which the firm completed and delivered to the Admiralty during the War. The time occupied in the construction of this vessel, in her shed, was about 6 months.

"R-34," subsequent to her trial flight, completed with satisfaction an endurance non-stop flight of 19 hours, during which trial all kinds of weather were encountered, rain, fog, snow, mist and squalls, but the vessel was able to carry out her program of visiting Ireland and otherwise circling about the British Isles before returning to her large hangar at Inchinnan.

Sundry details are being carried out at the moment and it is expected that the British Admiralty will permit the vessel to start the voyage across the Atlantic at an early date. The vessel has been fitted with fuel tanks of sufficient capacity to enable the journey to be effected easily, and she also possesses all other necessary requirements.

Carburetion of Low Grade Fuels

Some Points on the Design of Inlet Manifolds for Heavy Fuel Engines—Easy Bends vs. Chokes at Crotches

By O. H. Ensign

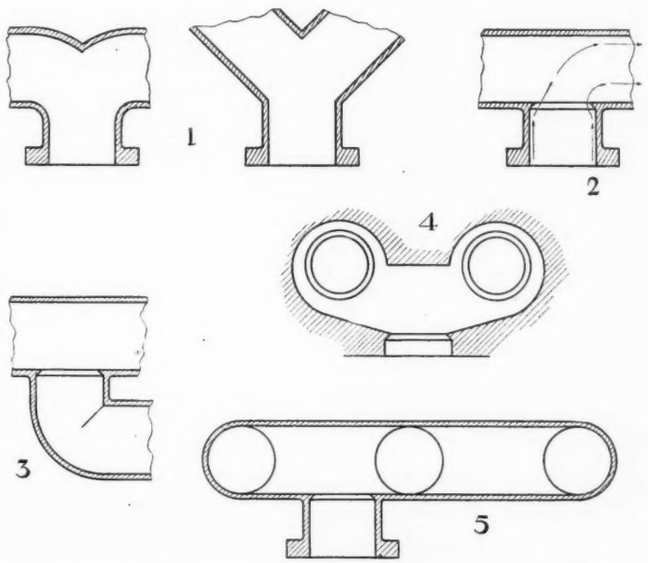
ONE of the most difficult problems in connection with the present fuel situation is the correct design of manifolds. Most of the existing automotive apparatus has been designed around the requirements of an easily vaporized fuel. Such a fuel approximates in performance a mixture of air and fixed gas, and in the design of manifolds it is necessary only to consider the fluid friction of the mixture and the absolute pressure loss involved in the change of direction at branches and Y's. But modern gasoline has an initial boiling point as high as 150 deg. and an end point as high as 450 deg., which calls for an entirely different solution of the problem, and this remark applies all the more strongly to any efforts to burn kerosene or distillates between kerosene and our so-called gasoline.

We are compelled to consider the practical use of a so-called wet mixture, for as soon as we get into the realm of the perfectly dry mixture, the size of the engine, its weight and expense rise rapidly; so the attack of the problem must be along the line of making the best use of a mixture, which involves utilizing the lighter bodies of the fuel with enough heat to make sure of good ignition and flame propagation, and of carrying the heavier constituents into the engine cylinder, finely enough divided and homogeneously distributed through the mass of mixture to give correct or reasonably correct combustion. In other words, to vaporize a portion by the use of vacuum and heat, and by turbulence and agitation, continued right down to the opening of the valve, to mechanically handle the heavier elements in such a manner as to bring about the above result.

It has been demonstrated that when a well vaporized mixture passes through an elbow there is always considerable condensation. Therefore, beyond every elbow and at every turn or branch, the mixture should be violently agitated, because poor distribution to the various cylinders and lack of homogeneity of the mixture in any cylinder may be easily demonstrated to be much greater causes of power than the friction involved in the following constructions.

Y branches such as shown in Fig. 1 are decidedly wrong for low grade fuels. Assume the mixture approaching such a Y branch with the fuel uniformly distributed throughout the stream of air; when coming to the Y, the fuel being denser than the air, part of it that should go to the right, will pass right on and fall dead in the quiet air to the left, being deflected by the "splitter." This fuel is picked up by the next impulse to the left, with the result of a puff of black smoke from the exhaust after it has reached the cylinder. In order that all cylinders may get sufficient fuel for each explosive impulse, the mixture must be made richer, because, as above described, a portion of it is separated from the air into relatively large drops and is not available as explosive fuel.

The proper construction for a branch is shown in Fig. 2. The arrows show how the fuel flows with the air in the right direction. The fuel in the air stream nearest



INTAKE MANIFOLDS—1, *Ordinary manifold joints with "splitters" (defective).* 2, *Proposed design of manifold.* 3, *Elbow with sharp inner edge.* 4, *Siamesed valve passage.* 5, *Recommended design of triple outlet manifold*

the side calling for it is thrown into the center of the stream, and that from the opposite side is deflected in the right direction. There is excessive turbulence at such a branch, not easily shown by arrows, and remixing occurs. Also there is always more or less of the heavier fractions on the walls, in liquid form, and with this construction these globules are thrown out into the air stream again and remixed. Fig. 3 illustrates the construction which should be followed in passing an elbow; the inner edge should always be sharp. As mentioned above, the mixture in passing around an elbow is separated more or less from the air stream. Immediately beyond the elbow there should be a sharp edge choke that will tend to throw this fuel back into the air stream. Fig. 4 represents the ideal construction for connection to siamesed valve pockets. Here again we have a branch, but by setting the wall opposite the entrance so that it is about on the center line with the two intake valves, we obtain an increase in flexibility, power and economy, for in this case the fuel mixture is properly maintained until it enters the cylinder, upon entering which it is again broken up and finally delivered in the form in which it will develop the maximum mean effective pressure.

There is a great variety of manifold designs for connecting up three or six cylinders. Fig. 5, laid out in detail as explained above, will give by far the best results and is the simplest form possible. The writer has

(*Continued on page* 1353)

Study of Air Resistance and Air Flow

Laws of Air Resistance Determined for a Wide Range of Air Speeds—Eddies Produced by Obstacles—Practical Applications to Aircraft and Automobile Problems

By H. Levy, M.A., D.Sc., F.R.S.E.*

THE problem of the forces brought into play by the motion of a body through the air at rest, or, what is in many respects identical, by the steady motion of air past a body at rest, is one which, although it has sprung into importance during recent years on account of the rapid development of aerial flight, is of no small consequence in other branches of engineering. The question has long been recognized as one which vitally affects such questions, for example, as the design of bridges and light buildings exposed to the forces of winds and gales. On the other hand, automobile engineering design, in common with other branches of locomotion, fighting as it is for the last inch in efficiency, cannot afford to neglect the effect of wind resistance to its motion and modifications that might be introduced into design, both to reduce this parasitic force and to minimize the effect of the associated evils of dust raising.

These are only a few of the branches of engineering to which the question should appeal with cogency, but it will become apparent that the question of air flow is not alone applicable merely to the motion of bodies in air, but is exactly equivalent to the corresponding problem of motion of bodies through water. There are at once, therefore, opened up whole fields of marine engineering on which an analysis of the problems of fluid flow will throw light.

In illustration, the exact contour of the hull and shells of sea craft of all descriptions, including submarines, torpedoes, etc., cannot possibly be accurately determined without a thorough knowledge of the forces due to the interaction between the body and the fluid, while the magnitude and directions of these forces are determined entirely by the nature of the flow set up by the body in its neighborhood.

Understanding of Medium First Essential

Before coming to a detailed study of the disturbance set up by a body in its motion and the resistance experienced, it is necessary to understand clearly the properties of the medium, air, upon which the whole phenomena depend. Although for the moment we restrict ourselves to a gas, the parallel with a liquid—water in general—will be brought out shortly.

It is an accepted fact that any volume of air is ultimately composed of an immense number of discrete molecules, flying about in all directions, each molecule possessing its own mass and velocity. By the impact of these molecules against the side of any vessel containing it, or against the surface of any body immersed in the gas, a pressure is originated whose magnitude at any point may be measured by the change of momentum experienced per second, perpendicular to the surface, by the molecules impinging on unit area. That is to say, we may conceive the body as being a man bombarded on all sides, and at every point of him, by footballs, so that the pressure he will experience will depend on the change in velocity of these balls on the rebound. The pressure thus originated may be regarded as a static pressure which exists even when the body is at rest and is what is commonly recognized, in the case of a liquid, as the hydrostatic pressure. An extra complication arises, however, if the body be in motion, for the particles of gas impinging upon it will not otherwise come into being.

In essence, the distinction between the two cases is equivalent to that which occurs where a football strikes a foot at rest, and where the football is deliberately kicked. The pressure on the foot in the latter case will in general be greater. On the surface of the moving body therefore an additional pressure—it may even be a diminished pressure if the foot be moving away from the ball on impact—will be experienced at each point, frequently referred to as the dynamic pressure.

Skin Friction

If the effect of the body, however, were merely to cause a change in momentum perpendicular to the surface, many of the complications that arise in aerodynamic and hydrodynamic analysis would be removed, but an additional trouble arises due to the fact that at the surface of the body there is a distinct tractive effect, some of the molecules of the gas becoming involved in the molecules of the surface of the body, with the result that the latter continually drags in its neighborhood a layer of the gas it would otherwise throw off. There is originated as a consequence a surface dragging force recognized under the more common name of skin friction. To this, however, we shall return shortly.

Before it is possible to proceed further, it is necessary to extract from this exceedingly complex state of affairs the properties of the gas which can be recognized as vital for determining the phenomena.

To trace out and sum up the effects of the impacts of the individual molecules, is clearly impossible. But this continual sweeping of the particles to and fro in all directions produces in the gas as a whole three distinctive properties which if once postulated may be regarded as defining the medium. The question will be approached by regarding the sum of the effects due to the rapid series of impacts really as an average effect.

The particles at any instant enclosed in any small region have each their own velocities, but there will, however, exist over the region an average velocity, average both in magnitude and direction. Each molecule possesses its own distinctive mass, but the total mass in a unit volume can be considered as the density of the gas at that point, and on this will depend the amount of momentum which can be communicated to it

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by impact with the body, either directly or indirectly through the medium of other masses of gas. Density therefore is the first property we must lay down.

The next property will depend on the nature of the force exerted by one layer of the moving gas on its neighbor.

Suppose A and B be two adjacent layers of gas, both moving in the directions indicated by the arrows, the average velocity in A, however, being slightly greater than that in B. The molecules in A do not always remain there, but flying about in all directions some of them will become inveigled in the layer B, while at the same time an equal mass from B will become inveigled in the layer A. The result of this is that A increases the momentum of B, while the latter tends to decrease the momentum of A. There is, in fact, along the surface between the two layers a rate of change of momentum, or in other words the equivalent of a force. This applies to all regions of the gas in which there exists a variation of gradient and velocity, and this dragging force of the one layer on its neighbor is known as the force of viscosity. Viscosity, in fact, is the second and in many respects the most important property of the gas.

There is one remaining property which concerns us. By the application of an external force to any volume of the gas—it may even be by the forces originated within itself by its own motion—the volume may be decreased or compressed. It is clear that if this should take place to any appreciable extent, not only will energy be used up in the compression, that is to say, not merely will the resistance of the body causing the compression be increased, but the actual nature of the air flow may be fundamentally altered.

For the present purpose we need then to restrict ourselves only to these three principal properties: Air is dense; it is viscous; it is compressible.

Effect of Compressibility

Although, as far as the present discussion is concerned, air may be defined in terms of these three factors, and these three only, they are not all equally important in their effects on the resisting forces brought into play by the motion of a body in that medium. Experimentally it has been found that the stress to be laid upon each of them is largely a question of the speed of the body. During the war a large amount of aerodynamic analysis of this nature has been carried through, and one important fact in particular, recognized certainly to some extent before the war, has emerged. This is concerned with the extent to which compressibility affects the resistance. In Fig. 2 is shown a picture of the waves set up in air by the motion of a bullet. This has been obtained by using the fact that the refractive index for air varies with density, so that, as a consequence, if condensations or rare factions take place, these would show themselves on a photographic plate.

From this photograph it appears that compressibility waves of this nature are brought into being by bodies such as projectiles moving at exceedingly high speeds, but at moderate speeds these waves do not become apparent. It is clear that each of these waves contains a certain amount of energy which is being transmitted through the air, and originates from the body in its motion.

As a consequence, the resistance of the body would tend to increase at a much greater rate than it would otherwise do at those speeds at which these waves begin to make themselves evident. It would in fact appear that after a certain speed is attained, the effect of compressibility without which these waves could not originate becomes a very vital factor in the resistance.

If this critical speed lies anywhere in the region of the normal speed of flight for aircraft, compressibility is clearly a question which must be carefully scrutinized. If, however, as will be seen is the case, this critical speed is well above normal flight speed, no serious error may possibly be introduced by ignoring it, while the advantage of considerable simplification will be obtained.

Analysis of Shell Motion Valuable

Recent analysis of the motion of shells in gunnery has afforded just the evidence required, for here we have a body projected at an extraordinarily high speed and slowing down by the retardation of the atmosphere. If the resistance of the shell at each point of its path could be measured it could then at once be determined from a consideration of this resistance whether a critical speed of the type anticipated exists.

The results obtained have afforded a startling justification of the theory. At first sight it appears an extremely difficult problem to determine the resistance of a projectile varying as it does from point to point, but a simple analysis of the following nature gives accurate enough results. Shells of the same type are projected at the same initial velocity and elevation, passing all approximately along the same trajectory.

By altering the fuse setting the shells may be made to burst successively at different points of the path and the times taken between firing and bursting. From these the trajectory may be drawn and the time of arrival of the shell at each point marked upon it. It is then no difficult matter to obtain by graphical means the speed and deceleration of the shell at each point. The resisting force on the body is then easily estimated from the deceleration by the usual application of Newton's laws of motion. A chart can then be constructed showing the variation in resistance of the shell for the large range of speeds passed through in its motion, viz., approximately 2200 feet per second to 300 feet per second.

To illustrate the law of resistance and its dependence on speed, however, it is not necessary or even most instructive to plot resistance as ordinate. Numerous experiments have shown that most bodies, at normal speed, experience a resistance to flight approximately proportional to the square of the speed, and the divergence from this law can best be seen, not by plotting resistance against velocity, giving a curve approxi-

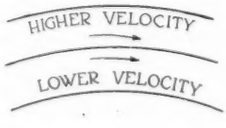


Fig. 1—Diagram to illustrate air viscosity

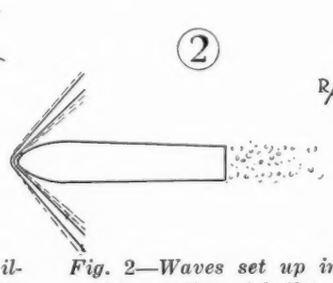


Fig. 2—Waves set up in air by motion of bullets

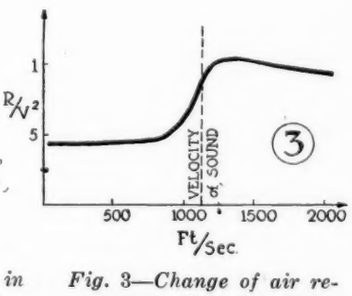


Fig. 3—Change of air resistance with air speed

mately parabolic, but rather resistance divided up by the square of the velocity giving approximately a straight horizontal line.

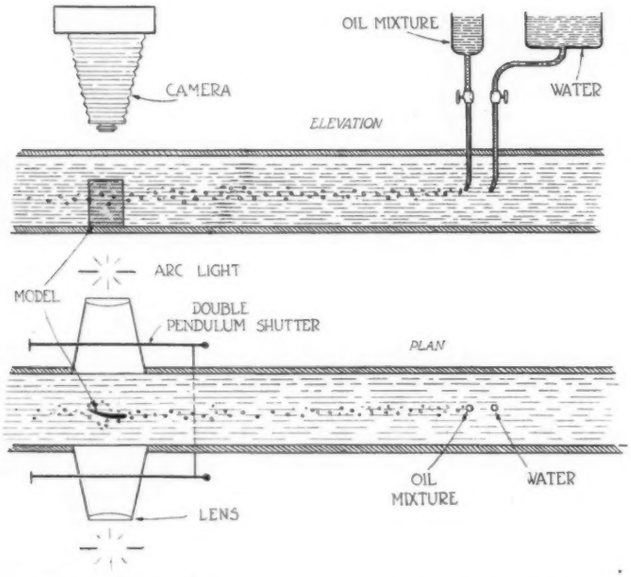
In the case under discussion therefore the most instructive manner of representation will be by plotting R/V^2 against V, where R = resistance and V = velocity. The chart obtained for the case of the projectile is then that shown in Fig. 3.

An examination of this curve indicates a rather remarkable phenomenon. It shows that up to speeds somewhat below the velocity of sound in air, up to say 500 ft. per second, the resistance is practically proportional to the square root of the velocity. In the region of the velocity of sound, resistance increases with great rapidity, evidently according to some much higher power than the square, and then, well above this critical speed, it tends to revert once more to the square law, although at a higher consant of proportionality than previously. This remarkable result fits in quite consistently with the considerations previously brought forward.

Well below the velocity of sound the body in its motion expends very little energy in the production of compression or sound waves. The resistance is almost entirely due to viscous forces. As it approaches the speed of sound, waves commence to be produced, traveling off ahead of the body at approximately 1100 ft. per second. When the body moves itself at this speed it rides on the crest of the waves, which it itself produces, while above this speed it cuts into undisturbed air, leaving its waves behind.

Incidentally, an interesting conclusion in gunnery may be at once deduced. For a body such as a shell or projectile which cleaves its way through the air at a speed well in excess of that of sound, a sharp pointed and tapering nose will clearly be most efficient, since by this means the energy lost in cutting through the medium would be reduced to a minimum, while the effect of the rear part of the shell must of necessity be of minor importance, since at these high speeds of flight where there is practically a vacuum behind the shell, the contour in that region cannot affect the nature of the air flow to any considerable extent.

From the point of view of the present discussion, however, where we are concerned with investigating the



Figs. 5 and 6—Plan and elevation of water channel for experimental determination of lines of flow

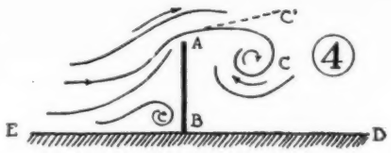


Fig. 4—Eddies produced by a flat plate perpendicular to line of motion

properties of air that are of importance in affecting the resistance at normal speeds of flight, an extremely important deduction follows from the foregoing conclusions, viz., that the property of compressibility upon which the production of sound waves depends may at normal speeds be completely ignored, and we are accordingly left with the simple fact that the whole problem for us depends purely on the density and the viscosity.

This conclusion immediately opens up to us an experimental method of handling these problems where otherwise grave difficulties would be experienced. To study the flow of air in the vicinity of a moving body, to determine where and how the eddying motion is produced and its effect on the resistance is extremely difficult in the case of air on account of its invisibility. But since, as has been shown, only density and viscosity are the important factors, while the air may be regarded as incompressible, we may have recourse to any other fluid which is dense, viscous and practically incompressible, provided the motion set up may be rendered visible and the exact law of comparison, the conditions under which deductions from the fluid to the air is clearly understood.

A substance satisfying these requirements is water, which is both dense and viscous and to all practical purposes incompressible. By a method shortly to be described it will be seen that the motion of the individual particles may be quite easily followed.

Consider what takes place in the neighborhood of a flat plate A B, Fig. 4, placed perpendicular to the direction of the streaming, whether of air or of water, E D being a wall. Such a case occurs, for example, with the wind screen of an automobile in motion, the blade of an oar moving in water, or the passage of a wind past a billboard or building.

Along A B the fluid is retarded in its motion, the stream line A C which just misses the edge would normally, in virtue of the inertia of the motion, be shot off along the direction of A C'. The particles of the fluid, however, in virtue of the retardation and viscous forces of the layers in their immediate neighborhood are reduced in motion and compelled to move along a path of smaller radius of curvature.

Similar causes continuously operating drag the particles further and further inwards, so that just beyond the edge a form of eddy or whirlpool is produced. It is a familiar enough experience to feel the back draught of this eddy on the rear seat of an omnibus or to produce the actual whirlpool as dimples on the surface of tea by gently drawing the tea spoon through the fluid.

Much of the dust raising due to the motion of a motor car along a road is undoubtedly caused by the particles of dust on the surface of the road being caught in these whirlpools as they are produced behind the car in its motion. Improvements in connection with these difficulties could undoubtedly be secured by simple modifications in designs, so arranged as to reduce this eddying to a minimum. Before this can be achieved, however, an accurate study of the conditions under which eddying is produced must be made.

The experimental method of analyzing the process that takes place during the flow past a body is exceedingly simple and interesting. An accurate study of the

problem demands a knowledge not merely of the lines of flow or stream lines past the body, but a measurement of the speed of the fluid at each point. This is necessary for numerous reasons but principally because from a knowledge of the distribution in velocity can be determined which regions of the fluid and which portions of the body are chiefly responsible for the dissipation of energy in the fluid and, therefore, for the production of resistance.

The experiment is conducted in a water channel 4½ in. wide by 6 in. deep approximately and about 3 or 4 ft. long, fed continuously by water at a head sufficient to maintain the speed at about 1 in. per sec. For accurate work it is extremely important to keep either the speed or the dimensions low; in fact, to keep the product of the speed and breadth small, since when this quantity attains above a certain value it is impossible to obtain steady flow in the channel. This is consistent

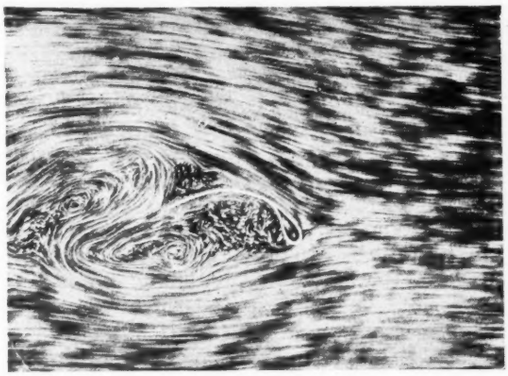


Fig. 4a—Flow of fluid past barriers

with the general statement that for all problems of flow past bodies there is a critical value of $v\,l$, where

v = speed of the body,
l = length of body,

above which the flow passes from one of uniform streaming to violent tubulence. This is equally true whether it be the flow through a pipe or channel or the streaming past an obstacle, but the corresponding value of $v\,l$ will be different in each case. It can be shown, in fact, to depend only on the shape of the body concerned. In the present instance where it is necessary to study the flow past the body, and as far as possible to eliminate the effect of the walls of the channel, it is exceedingly important to keep the value of $v\,l$ sufficiently low to be well below the critical for the channel itself. A rough indication of the principal features can be seen from the diagram, Figs. 5 and 6.

Details of Experiment

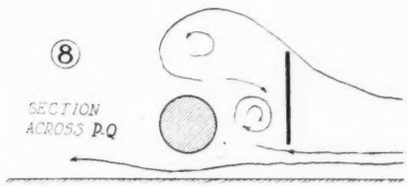
The light from the arc lights is projected by means of the cylindrical lenses as long, narrow beams onto the glass sides of the channel. This glass is blackened except for a narrow horizontal slit so that only a very narrow layer of the fluid in the channel in the neighborhood of the model gets illuminated, while by means of the double pendulum this light may be cut off periodically at intervals of, say, one-half second. To render the motion of the fluid particles visible a mixture of xylol and carbon tetrachloride in certain proportions gives a fluid which is of the same density as water so that it floats, but forms spherical drops in it like oil. The very small particles of this oil which are allowed to float along the channel past the model are

Fig. 7—Diagram drawn from photograph showing lines of flow past thin plate

produced by means of a simple form of atomizer, whose position in and relation to the water channel is obvious from Fig. 5.

The very small globules of oil produced at the atomizer A float down the channel, and those which lie within the thin layer of fluid illuminated by the arc lamps are visible from above as a series of brilliant points of light, alternately appearing and disappearing for intervals of one-half second as the light is shut off by the double pendulum.

Under these circumstances a loaded camera placed as in the diagram vertically above the region of the model, and focussed on the illuminated plane in the fluid, will take an image of the system of stream lines and provide the speed of each point, for each brilliant point of light will appear on the photographic plate as a series of dashes along the path it traced out in its motion, each dash being proportioned in length to the distance traversed in the half seconds during which the field was illuminated. The lengths of these dashes are therefore proportional to the speed of the fluid at the midpoint of the dash. Such a photograph of a simple nature is that shown in Fig. 7, representing the flow past a thin plate.



An analysis of the flow of liquids along these lines has thrown a considerable amount of light on the conditions under which eddying originates, and on the relation between resistance and eddying. It has become apparent, for example, that for a body of given shape at a particular value of $v \times l$, violent eddying originates in the rear of the body. If the nose of the body be nicely rounded with a tapering tail the eddying or turbulent region becomes confined to a narrow region in the wake; the nar-

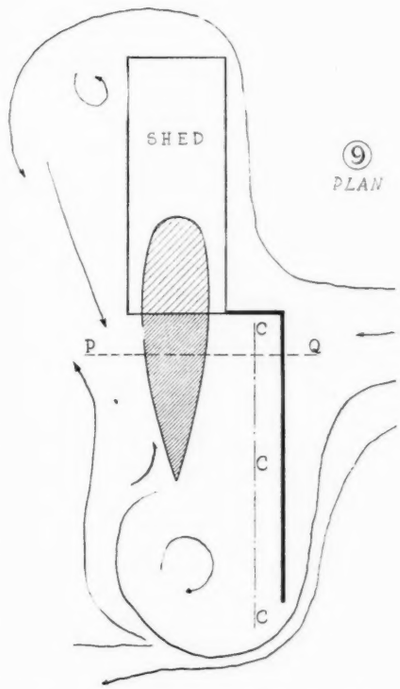


Fig. 8—Illustrating effect of air eddies on dirigible while entering hangar

Fig. 9—Arrangement of screen for hangar designed to prevent dirigible being pumped against ground

rower this wake the smaller the resistance. For example, the resistance of a wire or circular rod can be diminished to almost one-sixth of its value by fixing a fairing piece to the rear, the presence of this additional piece facilitating the smooth flow of the air. This principle is utilized in the design of aircraft to a very great extent, even to minute details. Struts, body, wires, and even nuts, are all smoothed and tapered off to reduce the parasitic resistance to a minimum.

But it is not merely in its effect on resistance that eddying is of such importance. The problem of housing airships, bringing them into and removing them from their sheds has raised many difficult problems. A gust of wind eddying over the edge of the airship shed may circulate in the region of the ship, buffet it about and dash it into the ground. In the early days of the war difficulties of this nature caused much worry and anxiety, but experimental analysis of the flow of air in the neighborhood of airship sheds and screens served to throw considerable light on the problem at issue. Smoke issuing from thin pipes, small balloons attached to strings, and, when dealing with wind channel tests on models, small pieces of cotton wool attached to the ends of silk threads were all used to show the direction of air-streaming, where and how the eddying, turbulence and circulation arose.

The annexed diagram, Figs. 8 and 9, gives a rough plan of the shed and simple screen, with the airship half out of the shed. There are in general three centers of violent turbulence. A form of whirlpool is thrown off from the vertical edge of the screen, inflicting by the back draught a heavy blow on the tail of the ship, driving it into the screen. Superposed on this, but not nearly so violent, is the eddy formed at the vertical edge P of the shed. Both these centers of disturbance have the effect of driving the tail toward the screen. But a much more insidious eddy is formed than either of these two. The top horizontal edge of the screen, acting as an eddy-forming center—an eddy with horizontal axis C C C—gives rise to a violent down draught on the top of the airship, tending to drive the tail into the ground. For practical purposes an upward force would not have serious drawbacks, as it could be counterbalanced by dragging ropes, but a downward pressure cannot be directly warded against. To counterbalance this, the lower edge of the screen is not allowed to reach the ground, but about 6 ft. of clear space is allowed to permit the wind to enter below the ship and exert an upward pressure. Fig. 8 gives an indication of the nature of the air flow resulting.

Although all the evils caused by these eddying centers

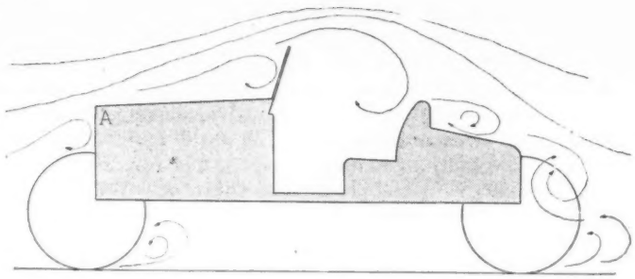


Fig. 10—Eddies produced by motion of automobile

cannot be avoided, by a suitable adjustment of the screen with reference to the prevailing winds, suitable fixing of heights and spacings, their effects may be considerably mitigated. The diagrams given indicate that the prevailing wind is at right angles to the direction of the screens. As the vertical edge of the screen is turned in a clockwise direction, the center of turbulence moves farther and farther off, until when the vertical edge has been turned through about 50 deg., the effect is almost inappreciable. As far as the present discussion is concerned, it is sufficient to note that by an analysis of the type of flow and the principal factors affecting it, the nature of the forces brought into play may be predicted and to a considerable extent safeguards taken.

From the general considerations outlined above and illustrated, a fairly accurate picture may be drawn of the nature of the air flow in the neighborhood of a body of almost any given shape—experiments analyzing the flow of air past the projecting portions of an automobile and the forces on the component parts measured with a view of determining whether reductions in resistance can be secured by suitable modification. Roughly, the nature of the flow is of the type shown in Fig. 10.

Several points at once become apparent. The eddying of a violent nature behind the body of the car, coupled with the eddying behind the wheels, will tend to pick up the dust in whirlpools. A more streamline overall shape would undoubtedly help to diminish this. The presence of sharp projections, as cited, likewise contribute to the parasitic resistance. Two cars fitted with different bodies and tested for resistance showed that at a speed of 30 miles per hour nearly 1 hp. could be saved by simple body considerations alone, while the mudguards, to which generally no attention is paid with a view to diminishing their parasitic resistance, are responsible for fully half the total air resistance of the complete car.

Commercial Aviation in Australia

ALREADY there are in existence in Australia three companies formed for the expressed purpose of engaging in commercial aviation. They are probably only the first swallows of the aeronautical summer that is about to burst upon us, for legally, as far as aviation is concerned, this continent is still under the shadow of the War Precautions Act.

So, as already prognosticated in these pages, civil and commercial aviation is upon us before Australia is ready for it. In the case of every one of these companies, it looks as though the money of the shareholders will have to be spent on work that should long ago have been done by the Government.

If a company proposed to start a motor service between Sydney and Manly, it does not expect to have to survey a road, build bridges or inaugurate a punt service at the Spit. Both our Governments—National and State—knew that commercial aviation was most assuredly coming. Also, they both knew that the war would end some day, and that if it ended in our favour there would be some hundreds of first-class, war-trained aviators returning to this country.

They owed it to themselves and the country to see that Australia should have the benefit of that splendid material.

However, nothing has been done.

Fortunately this is a business in which it is never too late to mend. There is nothing to prevent the Australian or the various State Governments starting a hurry-up movement in connection with aviation. In fact, they simply have to get the proverbial move on. Aviation is like every other great world movement, and will wait for no Government. It is here. If the Goverment isn't ready to meet it, so much the worse for the Government, and those whom the Government represent. It is as impossible, once peace is declared, to prevent the Australian people taking to the air as it was to prevent them taking to the surf some decade and a half ago. They'll do it, for a certainty. From *The Motor in Australia.*

Farm Tractor Design

A Mathematical Discussion of Some of the Problems That Must Be Solved, Together with Tabulated Data on Power Requirements, Soil Packing and Other Items

By Joseph Jandasek, M.E., E.E.

A GREAT deal of matter has been written about farm tractors, but most of it deals with the subject in a popular way. Such articles, while useful in their proper sphere, are of little value to a practical tractor designer. The tractor has already passed its period of invention and is now a manufacturing object; therefore, the cut and try methods by which most of the machines have been built in the past will no longer do. To turn out a good product, the design and development of a new machine must be placed in the hands of an experienced engineer who is thoroughly posted on the subject from the theoretical as well as the practical point of view. It cannot be emphasized too strongly that theory and practice must always go hand in hand and support each other, if we want to obtain the best results. Among our technical men there is a strong prejudice against the mathematical theory of machines, and many a first-class engineer, dreading the reputation of an over-technical theorist, rather adopts an inferior but more conventional method of design. This attitude, however, is bound to change gradually, to the benefit of our industries in general.

Tractors will be needed in almost every part of the world. Our tractor manufacturers have at present exceptional opportunities to secure a good foothold on foreign markets, if they only offer the right product, i.e., a product built on principles of quality and service. We must not forget that the foreign maker also is devoting his attention to the tractor. We know that he is making a very thorough investigation of the results that we have already obtained, and there is no doubt that he is going to make use of our experience and build on the basis that we have established. If we do not look out, he may eventually reach a higher plane of development than we.

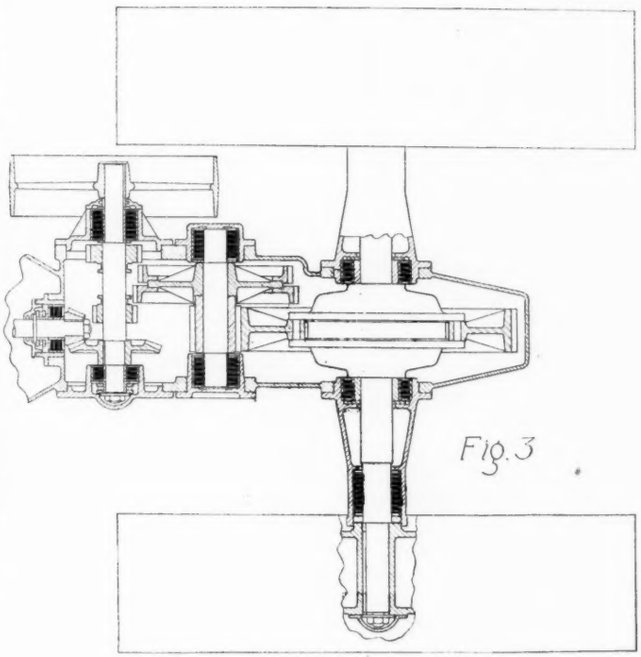


Fig. 3

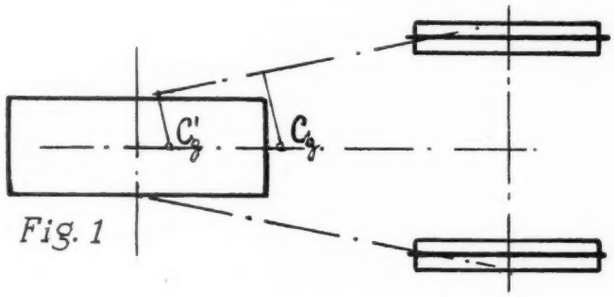


Fig. 1

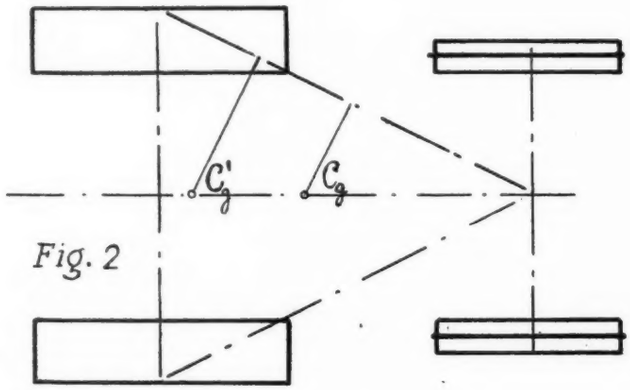


Fig. 2

To retain our supremacy in the tractor industry we have to put our research work on a more scientific basis. The world war proved unquestionably how much real scientific research work is worth to a nation. No matter how perfect a product seems to be, there is always room for improvement, and as long as the tractor is still far from a state of perfection there is much room for improvement. Most of the larger manufacturers have their experimental departments, but they are still very often conducted on the old cut-and-try principle. If the research work were carried on in the right manner and by men properly fitted for the task, it would be of great value for the concern in particular and for the whole tractor industry in general.

Before starting the design of a new machine the designer should get thoroughly acquainted with the status of the art, study carefully the existing machines and

Fig. 4

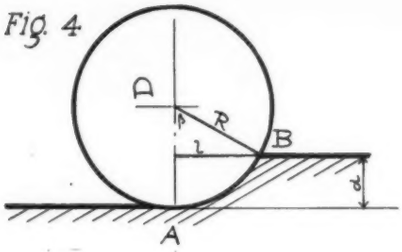
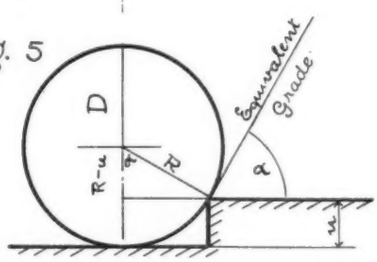


Fig. 5



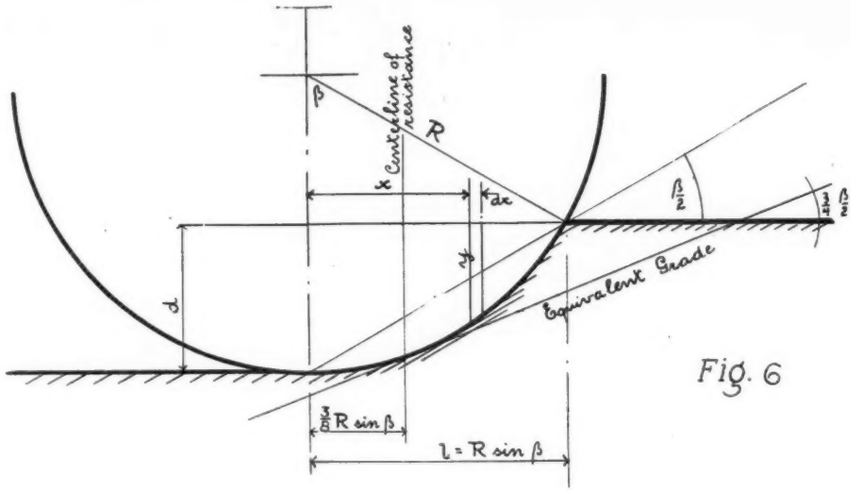


Fig. 6

familiarize himself with the latest trends in tractor design.

We may divide motor propelled farm vehicles into three distinct classes:

1. Motor plows, i.e., tractors carrying plows under them. This type of tractor is not very popular, because placing the plows under the machine makes the latter very high, heavy and clumsy, and the plows are not readily accessible for cleaning and other purposes.

2. Plain tractors, which can be used for plowing, harvesting, planting, belt work, road hauling, etc. This is the most popular and within certain size limits the most economical machine for use on the farm at present; it is also the best manufacturing proposition in the tractor field.

3. Motor cultivator and garden tractor. These machines are the youngest members of the tractor family, and, at present, in their first stage of development. However, there are great possibilities for the future along these lines.

Having decided what kind of machine to build, we must next determine its capacity or size.

In the plain tractor class the most useful machine for the average farmer is a three-plow outfit, though it seems that the two-plow tractor is destined to be the favorite and the biggest seller. Practical tests have proved that a three-plow machine is superior to a two-plow, because it can run also a small grain separator and is more economical as to fuel consumption. With a three-plow machine one man can accomplish 50 per cent more work than with a two-plow outfit of the same speed. In brief, a three-plow tractor works more economically. For large farms, of course, a four-plow tractor is still more suitable than the three-plow, and there will always be a reasonable demand for machines of the larger sizes.

The weight of the tractor should be reduced as much as practical to prevent miring in soft ground and packing of the soil. At the same time we must, however, provide for sufficient strength of parts to prevent breakage and keep the unit stresses below those of automobile and motor truck practice.

All working parts must be enclosed so as to be protected against dust and weather, yet readily accessible for repairs and adjustments. They must be constructed so as to be capable of working at full load for long periods and under all weather conditions, and require minimum attention. The lubrication should be automatic, and an effective cooling system should be provided. The material and workmanship must be first class throughout. Wherever the designer has a choice between two or more equally good constructions he should use the one which will require the least attention from the farmer.

What kind of driving members shall we select? Wheels seem to be the most logical, and the wheeled tractor will always have the widest market, because of the simplicity, reliability, endurance, small weight and low price of the wheels. Where, however, the tractor is intended for softer grounds we have to choose the crawler. A drum is not nearly as practical as wheels or as the crawler and therefore will not be considered here.

The four-wheel-drive tractor is naturally superior to a two-wheel-driven one when regarded solely from the traction point of view, yet, 90 per cent of the farmers can secure a sufficient amount of traction from a two-wheel-drive machine, and it would, therefore, be only an unnecessary outlay of money for them to buy the more

Fig. 7

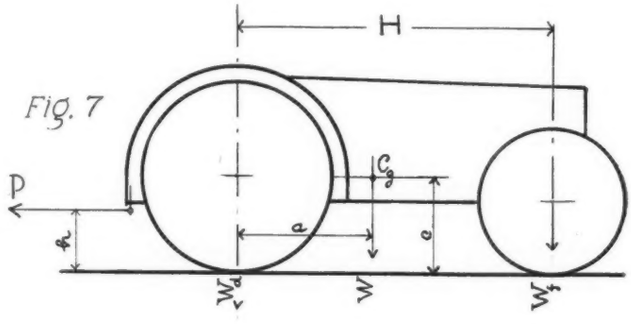
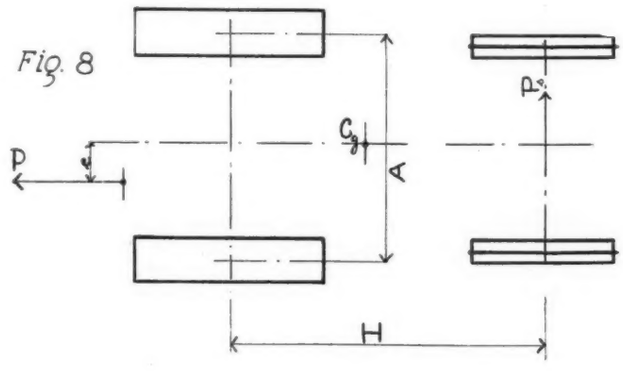


Fig. 8



costly four-wheel-drive tractor. Of course, when the territory is very hilly the four-wheel-drive tractor or the tracklayer type can be recommended, even if the original cost be higher. The two-wheel-drive tractor should have its two driving members located at the rear. This type possesses the greatest stability and the highest weight economy. When there is only one wheel in the rear, the machine is apt to tip over when pulling heavily, especially rounding corners or on side hills, because the more this machine pulls the lower is its stability. (See Fig. 1.) On the contrary, with two wheels in the rear, the more the machine pulls the greater is its stability (see Fig. 2). The driving members should be located at the rear because with that arrangement the heavier the pull the greater the weight resting on the drivers.

The front-wheel-drive type does not have as good weight efficiency as the rear-wheel drive; still, it may be considered for machines of smaller capacity. For certain special kinds of tractor, front-wheel drive is even of advantage, as, for instance, two-wheel tractors so designed that the operator may sit on the implement; also machines intended for crossing ditches, mudholes, etc.

A single driving member in the rear is a recognized failure because of its poor stability (see Fig. 1) and is rapidly disappearing from the market.

Two front wheels for steering are unquestionably better than one, because a single front wheel located on one side introduces difficulties in steering in soft ground or on side hills. When placed in the center, the forward end of the tractor must stand also all the bumps and shocks of a worn-out country road. Therefore, three-wheel tractors are constantly loosing ground and in the future will probably be discarded entirely.

Transmission Should Be Straight Gear Drive

The transmission of a modern tractor should be a straight gear drive, all enclosed and running in a bath of oil, and a responsible tractor designer endeavoring to turn out a quality product will not decide for anything else. Not a single gear must be left exposed, no friction drive or open chain drive can be considered. Spur gears are to be used wherever the construction permits, because they are the most reliable and can stand the most abuse. Bevel gears are entirely satisfactory when correctly proportioned, though they are more sensitive than spur gears and require more attention. Worm gears cannot stand much abuse and require good and positive lubrication. How far this type of gearing will be practical for farm tractors remains to be decided. The use of the worm gear directly on a live rear axle does not seem to be very reliable, on account of the enormous tooth pressure resulting from the great gear reduction used on tractors. Consequently, the worm gears heat highly even when careful lubrication is provided. Nevertheless, some tractor makers are giving this type of gearing a trial and, for small and low powered machines, it may prove satisfactory.

Anti-Friction Bearings

As to bearings, the anti-friction types are the only ones to be considered, as they are most efficient, require little attention and, if well proportioned, run almost indefinitely without appreciable wear. The accompanying illustration (Fig. 3) represents a typical anti-friction transmission.

The longitudinal weight distribution is of paramount importance in the design of a tractor and will receive due attention in another part of this article. For the present it will suffice to point out that the more powerful the engine, the larger the gear reduction, the greater the height of drawbar and the greater the rolling resistance, the greater should be the proportion of the weight on the front wheels, in order to prevent tipping over of the machine when pulling heavily or while on steep hills. The center of gravity should be as low as possible so as to insure perfect lateral stability, while still leaving enough clearance.

Preliminary Calculations

After we have decided on the type and size of the machine to be built, the next thing is to find the necessary amount of pull and power.

The required drawbar pull is usually determined from the number of plows the tractor has to pull. It is usually considered that 700 lb. of drawbar pull is sufficient to pull one 14-in. plow in Middle West soils; but we must allow one-third more as a reserve for hard and tough places, which makes a total of 935 lbs. In other words, we need in the Midle West about 1000 lb. and in Eastern States about 1200 lb. of drawbar pull for every 14 in. bottom at plowing speed, provided that the tractor is equipped with a low speed for emergency, which low speed should be about two-thirds of the plowing speed in order to develop 50 per cent more pull. In case the plowing speed is at the same time the lowest speed, the necessary maximum drawbar pull should amount to 50 per cent more, i. e., up to 1500-1600 lb. for every plow to be guaranteed at this speed. This means the actual maximum pull and not the rated maximum pull, which should be only 80 per cent of the maximum pull. The average pull in lb. required in different soils for one 14-in. bottom, plowing 6 in. deep, is about as follows:

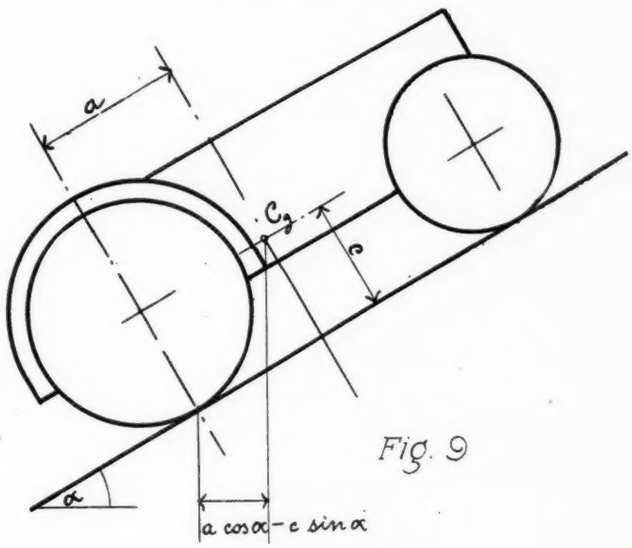


Fig. 9

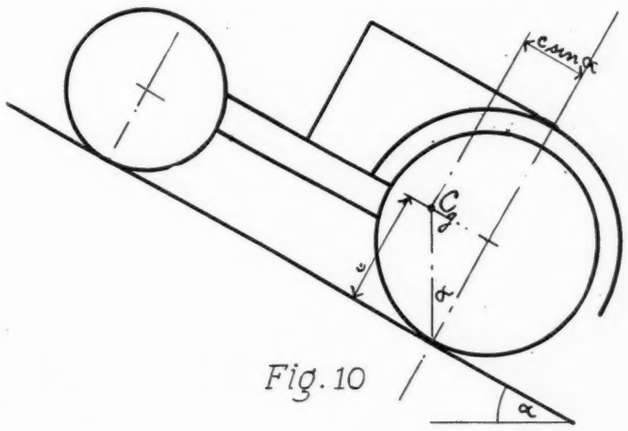


Fig. 10

Stubble	400-500 lb.	Sod	1000-1500 lb.
Clay	600-700 lb.	Gumbo	1500-1800 lb.

The drawbar pull needed for other implements runs about as given in the table below:

Binder, 6-8 ft.	800-1000 lb.
Grain drill, 7 ft.	400- 800 lb.
Disk harrow, 6-8 ft.	800- 900 lb.
Lister set	800 lb.
Double row cultivator	600 lb.
One-row cultivator	400 lb.
Corn planter	400 lb.

Weight

The total weight of a tractor should be in a definite proportion to the drawbar pull. We may say that under average soil and weather conditions the machine will pull about 80 per cent of its total weight. But since the rated maximum pull should be only 80 per cent of the actual maximum pull, the actual maximum pull at plowing speed may be equal to the total weight of the machine. The emergency pull at low speed may be up to 50 per cent greater. This maximum pull is available only for momentary use, as it would result in great slippage and loss of power when used for continuous operation. The above may be put into formulæ as follows:

$P_p = W$ lb. (on level soil for rear wheel drive) ..... (1)

$P_i = 1.5\ W$ lb. ..... (2)

where P_p = Max. pull at plowing speed.
P_i = Max. pull at low speed.
W = Total weight of tractor.

In taking the total weight of the tractor for W in our calculations we are making a slight error, as it is only the weight on the drivers at the heaviest pull that really counts. This is permissible, however, as with the rear wheel drive the weight left on the front wheels at maximum pull does not amount to much.

Rolling Resistance

The pull required to propel a vehicle on the level is equal to about 15 per cent of its weight in stubble plowing and up to about 25 per cent on soft soils. For light two-plow outfits with comparatively long and sharp spade lugs it amounts to about 20 per cent, while with tracklayers it is only about 12 per cent.

$t = 0.15$ lb. per lb. for stubble fields ..... (3)

$t = 0.25$ lb. per lb. for soft or recently plowed soils. (4)

t = is the traction effort or ground resistance in lb. per lb. of total tractor weight.

To simplify matters, in the following calculation t will be assumed to be a constant, while actually it varies with the size of wheels.

For grade resistance, i. e., the amount of pull necessary to propel a vehicle up a hill of a certain grade, it seems safe to take:

$g = 0.10$ to 0.15 lb. per pound of weight ..... (5)

provided the tractor is designed for fairly level countries.

Speed

The proper emergency speed is about 1¾ to 2½ m.p.h. The plowing speed can range from 2½ up to 3½ m.p.h. The tendency to-day is naturally toward higher speed in plowing, which is proving successful in districts with light soils, but is impracticable in stony fields. The proposed standard plowing speed of 2 1-3 m.p.h. is altogether too low for a modern machine. The actual speed is from 5 to 15 per cent lower on account of the constant slippage of the driving members. The high speed or road speed can be taken at from 3½ to 8 m.p.h. according to the weight, size and spring mounting of the tractor. There is no demand for more than three forward speeds; however, less than three speeds results in cutting down the efficiency of the tractor.

Horsepower

After we have decided on the speed and drawbar pull of our machine we can calculate the drawbar horsepower. Then, estimating the ground and grade resistance and transmission efficiency, we obtain the brake horsepower of the tractor. The formulæ for these calculations are:

$$\text{DHP} = \frac{P_p}{375} S_p \text{ drawbar horsepower} \quad \ldots\ldots (6)$$

$$\text{BHP} = \frac{P_p + (t+g)\,W}{375\,E_t} Sp \text{ brake horsepowers} \quad \ldots\ldots (7)$$

where E_t = Mechanical efficiency of transmission.
S_p = plowing speed in m.p.h.
$(t+g)$ = ground and grade resistance in lb. per 1 lb. of weight.

For a quick calculation of the available drawbar horsepower we can develop an easy formula by substituting in equation (7) as follows:

$W = P_p$ for light and high-powered tractors
$t + g = 0.25$
$E_t = 0.84$

$$\text{BHP} = \frac{P_p\ S_p}{375}\left(\frac{1+0.25}{0.84}\right) \text{ (3 gearsets)}$$

$$\text{BHP} = 1.5\ \text{DHP} \quad \ldots\ldots (8)$$

$$\text{DHP} = \frac{2}{3}\ \text{BHP (for light, high-grade machine)} \quad \ldots\ldots (9)$$

We can still further simplify the calculation of the pull P at 2½ m.p.h. since one horsepower is equal to 150 lb. pull at this speed; hence,

$$\text{DHP} = \frac{P}{150} = \frac{2}{3}\ \text{BHP},$$

and, finally,

$P = 100$ BHP at 2½ m.p.h. ..... (10)

That is, each brake horsepower is developing about 100 lb. of pull at 2½ m.p.h., on modern, light high-grade tractors.

Piston Speed

Tractor engines work about 80 per cent of the time at full load. Therefore, the unit stresses and pressures must be kept lower and the piston speed mustn't be as high as on automobiles or motor trucks, in order to prevent too rapid wear and other troubles. Also, the cooling system must be very effective. A normal piston speed of 900 ft.p.m. has proved very practical and is widely used, and it is not advisable to go much above this, especially not with the present four-cylinder engines. The formulæ for determining piston speed or r.p.m. are:

$$N = 6\frac{V_p}{L} \text{ r.p.m.} \quad \ldots\ldots (11)$$

$$V_p = \frac{LN}{6} \text{ ft.p.m.} \quad \ldots\ldots (12)$$

and that the ratio between stroke and bore is:

$$L = 1.25 \text{ up to } 1.4\ \text{B} \quad \ldots\ldots (13)$$

in which N = r.p.m.
V_p = piston speed in ft.p.m.
L = length of stroke in in.

In the table below are indicated the r.p.m. corresponding to a piston speed of 900 ft.p.m. for different lengths of stroke:

Stroke, in.	Speed, r.p.m.	Stroke, in.	Speed, r.p.m.	Stroke, in.	Speed, r.p.m.
4	1350	5¼	1029	6½	831
4¼	1271	5½	982	6¾	800
4½	1200	5¾	940	7	771
4¾	1137	6	900	7¼	745
5	1080	6¼	864	7½	720

When determining the necessary BHP of a tractor we have to take the belt work into consideration:

$$\text{Belt HP} = E_b \text{ BHP} \quad \ldots\ldots (14)$$

Where E_b is the efficiency of the gearset between the pulley and engine, if any.

The most important belt work is threshing, which at the same time is very hard on the engine. The horsepowers needed for threshing vary a good deal with the quality of the grain to be threshed. There is no general formula, but we can use the following table for determining the belt horsepowers required for different sizes of grain separators:

Width of cylinder	Required belt horsepower
18 in.	22 hp.
20 in.	24 hp.
24 in.	30 hp.
26 in.	34 hp.
28 in.	36 hp.
32 in.	45 hp.
36 in.	60 hp.

From the above table it will be seen that a tractor equipped with an engine under 30 hp. has only a limited belt work capacity and can be used only on small size farms or where there is another, larger source of power available for threshing.

Other machines, such as corn shellers, hay presses, feed grinders, ensilage cutters, etc., require usually from 8 up to 30 belt horsepower.

Assuming the standard belt speed of 2600 ft.p.m., we obtain for the diameter of pulleys

$$d = \frac{10{,}000}{n_p} \text{ in. (appr.)} \quad \ldots\ldots (15)$$

where n_p is the r.p.m. of the pulley.

Widths of pulleys may be made as follows:

6½ in. for machines of 16-20 BHP
7½ in. for machines of 20-30 BHP
8½ in. for machines of 30-40 BHP
9½ in. for machines of 40-60 BHP

For calculating the horsepower of belts and pulleys we can use the following formulæ:

$$\text{Belt HP} = \frac{d\ w\ n_p}{2860} \text{ for a pulley with a single belt}$$

$$\text{Belt HP} = \frac{d\ w\ n_p}{1720} \text{ for a pulley with double belt}$$

$$\text{Belt HP} = \frac{w\ s}{900} \text{ for single belt}$$

$$\text{Belt HP} = \frac{w\ s}{630} \text{ for double belt}$$

where w is the width of the belt in in. and s the belt speed in feet per minute.

Engine Dimensions

Assuming that the mean effective brake pressure with modern four-cycle gasoline engines equals 80 lb. per sq. in., we obtain for the calculation of the brake horsepower

$$\text{BHP} = \frac{B^2\ L\ N}{12600}\ 4 \quad \ldots\ldots (20)$$

$$\text{BHP} = \frac{N\ C}{\pi\ 12600}\ 4 \quad \ldots\ldots (21)$$

$$\text{BHP} = \frac{.7854\ B^2\ p\ V_p}{33000} \quad \ldots\ldots (22)$$

in which B is the cylinder bore in in.; p, the brake mean effective pressure in lb. per sq. in., and C the piston displacement in cu. in.

If we want to be more conservative and take the brake mean effective pressure at 72 lb., we have the well-known formula:

$$\text{BHP} = \frac{B^2\ L\ N}{14000}\ 4 \quad \ldots\ldots (23)$$

for 4-cylinder 4-cycle gasoline engines.

For determining the torque we can use

$$T = \frac{B^2\ L\ p}{4} \text{ in.-lb.} \quad \ldots\ldots (24)$$

or

$$T = \frac{C\ p}{4\pi} \text{ in lb.} \quad \ldots\ldots (25)$$

Substituting 900 ft.p.m. for V_p and 80 lb. for p in equation (22) we obtain for the brake horsepower

$$\text{BHP} = 1.71\ B^2 \quad \ldots\ldots (26)$$

and for the diameter of the bore we get

$$B = 0.765\sqrt{\text{BHP}} \quad \ldots\ldots (27)$$

In the following table are given brake horsepowers of 4-cylinder engines of different bores when the mean effective brake pressure equals 80 lb. per sq. in. and the piston speed 900 ft.p.m.

B in in.	BHP	B in in.	BHP
3½	21.0	4½	34.6
3¾	24.0	4¾	38.6
4	27.3	5	42.6
4½	31.0	5¼	47.0

If we assume that when kerosene is used as fuel there is a loss of 15 per cent in the horsepower of the engine, the above formulæ (26) and (27) become

$$\text{BHP} = 1.45\ B^2 \quad \ldots\ldots (28)$$

$$B = 0.83\sqrt{\text{BHP}} \quad \ldots\ldots (29)$$

for 4-cylinder 4-cycle kerosene engines.

As to the kerosene burning problem, it is the writer's opinion that any attempt to solve it by designing kerosene carbureters, manifolds, etc., is absolutely hopeless, because there are too many undeterminable factors regulating the vaporization of the fuel and the combustion of the mixture, viz., the quality of the kerosene used, temperature, heat conductivity, horsepower capacity, r.p.m., volume and velocity of mixture, shape of cylinder head and manifold, time, compression, etc. The only simple solution is to atomize the fuel positively by injecting it into the cylinder at the moment of combustion, so that there can be no recondensation. In this way all the spark plug, magneto and carbureter trouble would be eliminated. From my personal observation and experience with motors of the injection type, I can say that the Diesel engine is the most perfect and most reliable. However, being too complicated and too heavy, it does not seem suitable—at least, not in its present form—for propelling vehicles. The Brons motor (very similar to the Hvid) is reliable and very simple, though not as clean working and not as economical as the Diesel. As an engine for vehicle propulsion the Brons motor has, however, also a drawback. There is a slight irregularity in the timing of the explosion and it is impossible to regulate same. Direct liquid injection would be ideal provided that we could insure sufficiently fine spraying of the fuel. With all injection type engines the main problem is to regulate the minute amount of fuel necessary for each explosion.

Gear Ratio

The gear ratio of a tractor is

$$G = \frac{N}{n} \quad \ldots\ldots (30)$$

where n is the r.p m. of the driving wheels, which can be determined as follows:

Peripheral speed of wheel $= \frac{\pi\ D\ n \times 60}{12 \times 5280}$ miles p. h.,

and this is equal to the tractor speed S; hence

$$S = \frac{D\ n}{336} \text{ miles p. h.} \quad \ldots\ldots (31)$$

$$n = \frac{S}{D} 336 \text{ r.p.m.} \quad \ldots\ldots (32)$$

where D is the diameter of the driving wheels in in.

Substituting in equation (30) for n the value found in equation (32) and for N the value of equation (11) we obtain:

$$G = 16.1 \frac{D}{SL} \quad \ldots\ldots (33)$$

This is the gear ratio required for a tractor if the piston speed is 900 ft.p.m. For a tractor speed of 2½ m.p.h. (a good speed for hard plowing) this simplifies to

$$G = 6.44 \frac{D}{L} \quad \ldots\ldots (34)$$

Sometimes the r.p.m. of an engine are determined without taking piston speed into consideration. Usually, 900 r.p.m. is the speed selected, and in that case we have

$$G = 2.68 \frac{D}{S} \quad \ldots\ldots (35)$$

Further, for a tractor speed of 2½ m.p.h. and 900 r.p.m. of the engine we get the following very useful formula for quickly calculating of gear ratio:

$$G = 1.07\ D \quad \ldots\ldots (36)$$

Drawbar Pull and Horsepower

When the engine dimensions are given we can determine the available drawbar pull in the following way:

Torque on rear axle $= E_t GT$ in.-lb.

The corresponding tangential force is $2 \frac{GTE_t}{D}$ lb., and this is equal to the drawbar pull P plus the rolling resistance $(t + g)\ W$, hence,

$$P + (t + g)W = 2 \frac{GTE_t}{D} \text{ lb.}$$

$$P = \frac{2\ E_t\ GT}{D} - (t + g)\ W \text{ lb.} \quad \ldots\ldots (37)$$

Substituting for T from equation (25) we obtain

$$P = \frac{2\ E_t\ G}{D} \times \frac{Cp}{4\pi} - (t + g)\ W \text{ lb.} \quad \ldots\ldots (38)$$

The drawbar horsepower DHP can be calculated from the dimensions of the engine as follows:

$$\text{DHP} = \text{BHP}\ E_t - (t + g) W \frac{S}{375} \quad \ldots\ldots (39)$$

Equations (38) and the following equation are being used by the writer for comparing tractors of different makes:

$$\text{DHP} = \frac{N\ C\ 4}{\pi\ 12600} E_t - (t - g)\ W \frac{S}{375} \quad \ldots\ldots (40)$$

Wheel Sizes

When a wheel is rolling over soft ground it is supported only on a part of its periphery (AB, Fig. 4) ahead of the axle, because the soil is not elastic. The projected bearing surface equals lF, and since it is known from geometry that $l = \sqrt{(D - d)\ d}$ we obtain

$$\text{Area} = F\sqrt{(D - d)\ d} = F\sqrt{(D\ d - d^2)}$$

where d is the depth the wheel may be allowed to sink into the ground and F the face width of the rear wheels, both in inches.

Because d is very small in proportion to D we can safely omit the member d^2, which gives

$$\text{Area} = F\sqrt{D\ d} \text{ sq. in.}$$

For $d = 1$ in. we get:

$$\text{Area} = F\sqrt{D}$$

Allowing a mean pressure i in lb. per sq. in. of ground contact and making $d = 1$ in. we get the weight which can be safely supported by two rear wheels, or, in other words, practically the total weight of the tractor, as at heavy pulls almost all the weight is carried on the two rear wheels.

$$W = 2\ \text{i}\ F\sqrt{D} \text{ lb.} \quad \ldots\ldots (41)$$

Assuming i = 17 lb. per sq. in. we obtain

$$W = 34\ F\sqrt{D} \text{ lb.} \quad \ldots\ldots (42)$$

for the 2 rear wheels of width of face F in. each and

$$F = \frac{W}{34\sqrt{D}} \text{ in.} \quad \ldots\ldots (43)$$

When the tractor is standing still and not pulling, the weight resting on the front wheels is at its maximum and amounts to about $\frac{W}{3}$; therefore, for the 2 front wheels equations (41), (42) and (43) become

$$W_f = 2\ \text{i}\ f\sqrt{D_f} \quad \ldots\ldots (44)$$

where $W_f = \frac{W}{3}$ (approx.)

$$W = 100\ f\sqrt{D_f} \text{ lb.} \quad \ldots\ldots (45)$$

$$f = \frac{W}{100\ \sqrt{D_f}} \quad \ldots\ldots (46)$$

From the following table we can readily determine the supporting area in sq. in. of a wheel as well as the mean pressure i in lb. per 1000 lb. supported by a wheel of definite diameter and width, assuming the depth d that the wheel sinks into the soil to be 1 inch:

SUPPORTING AREA AND SOIL PRESSURE OF TRACTOR WHEELS

Supporting area $= F \sqrt{D}$ sq. in. mean soil pressure $= \frac{1000}{F \sqrt{D}}$ lb.

Wheel dia. in in.		Face of Wheel in inches								
		3	4	5	6	8	9	10	12	14
28	area....	15.9	21 2	26.4	31.8	42.3	47.6	52.9	...	...
	pressure	62.9	47.2	37.9	31.4	23.6	21	18.9	...	...
30		16.4	21.9	27.4	32.8	43.8	49.3	54.8	...	...
		61.0	45.7	36.5	30.5	22.8	20.3	18.2	...	...
32		17.0	22.6	28.2	33.9	45.2	51.0	56.5	...	...
		58.8	44.2	35.5	29.5	22.1	19.6	17.7	...	...
34		17.5	23.4	29.1	35.0	46.6	52.5	58.3	...	...
		57.1	42.7	34.4	28.6	21.5	19.0	17.2	...	...
36		18.0	24.0	30.0	36.0	48.0	54.0	60.0	...	...
		55.5	41.7	33.3	27.8	20.8	18.5	16.7	...	...
38		18.5	24.6	30.8	37.0	49.3	55.5	61.6	74.0	86.2
		54.1	40.7	32.5	27.0	20.3	18.0	16.2	13.5	11.6
42		19.4	25.9	32.4	38.9	51.8	58.3	64.8	77.8	90.6
		51.5	38.6	30.9	25.7	19.3	17.2	15.4	12.9	11.0
48		...	...	...	...	55.4	62.3	69.3	83.1	97.0
		...	...	...	...	18.1	16.1	14.4	12.0	10.3
54		...	...	...	...	58.8	66.1	73.5	88.2	103
		...	...	...	...	17.0	15.1	13.6	11.3	9.7
60		...	...	...	...	62.0	69.7	77.4	93.0	108
		...	...	...	...	16.1	14.3	12.9	10.8	9.3

We may use this table also for comparing mean pressures under the wheels of two different tractors; the greater the pressure under the wheels the more the soil will be packed.

Example: What is the mean pressure of ground contact with the following machines:

A—Weight 5000 lb., 2 rear wheels 60 x 10 in.
B—Weight 3500 lb., 2 rear wheels 48 x 12 in.
C—Weight 2800 lb., 2 rear wheels 42 x 12 in.

Estimating that when the machine is pulling, about 80 per cent of the total weight is carried on the rear wheels, we obtain:

Mean pressure i for A = 25.8 lb.; for B, 17.4 lb.; for C, 14.4 lb.

From the standpoint of soil packing the area grows directly with the width of face and only with the square

root of the wheel diameter. Wheels of large diameter have more area of contact, are more efficient and give more traction. Their main advantage, however, is that they bridge over obstructions better.

In Fig. 5 is shown a wheel in a hole u in. deep. In order to pull out, the engine must exert as much power as when pulling the weight carried on that particular wheel up a certain grade g. This grade can be determined as follows:

$$R - u = R \cos x$$

from which

$$R = \frac{u}{1 - \cos x} \quad \ldots\ldots (47)$$

$$\cos x = \frac{R - u}{R}$$

where x is the angle of equivalent grade $g = tgx$.

Provided the tractor is equipped with a power plant calculated to develop at plowing speed on the level a net drawbar pull equal to the weight of the machine, the tractor can climb up a grade of 45 deg. with small load. In this case equation (47) becomes

$$D = 6.83u \quad \ldots\ldots (48)$$

The table below gives the minimum diameters of wheels with which tractors having a drawbar pull equal to their weight could pull out of holes in the ground of a depth u provided both rear wheels were climbing at the same time, with all weight resting on the rear wheels at that moment:

D, in.	u, in.	D, in.	u, in.
20	2.9	42	6.1
25	3.7	48	7
30	4.4	54	7.9
36	5.2	60	8.8

In case the machine is equipped with an emergency gear reduction giving 50 per cent more pull than the plowing gear, the operator can shift into low and in this way make the tractor climb out of a hole corresponding to a 100 per cent grade and still be able to develop 50 per cent of its maximum drawbar pull P_p.

Thus it will be readily seen how important it is to select driving wheels of the proper diameter, and it is not advisable to go under 48 in., as otherwise the machine might not climb up even a shallow ditch.

As regards the size of front wheels, they must not be too small in proportion to the rear wheels.

Influence of Wheel Dimensions on Ground Resistance

It is no doubt of value to the tractor designer to have an idea regarding the relation between the wheel dimensions (diameter and face of wheel) and the rolling resistance, and, therefore, the following mathematical derivations were made.

Let us assume that there is no cohesion, no mud and no dust on the surface; that the pressure of the soil against the tire increases in direct proportion with the depth of depression; that the pressure is nil at the surface and q lb. when the soil is depressed 1 in. deep; we than have (Fig. 6) and

$$dW = qydxF$$

$$W = qF\int_0^l ydx$$

where the integral is equal to the area of the half segment which was displaced by the wheel. The value of q is in effect the carrying capacity coefficient of soil in lb. per cu. in. The area of the half segment (see Fig. 6) is $\frac{1}{2}R^2S - \frac{1}{4}R^2 \sin 2S$, where S is given in radians. The angle S is comparatively small, hence we can substitute for it $\sin 2S = 2S - \frac{(2S)^3}{6}$, and we then get

$$W_1 = \frac{1}{12} qFD^2S^3 \quad \ldots\ldots (49)$$

in which W_1 is the weight on that particular wheel only.

When q is determined by experiment for a certain soil the value of S can be determined for any size of wheel, for

$$S = \left[\frac{12W_1}{qFD^2}\right]^{\frac{1}{3}} (S \text{ in radians}) \quad \ldots\ldots (50)$$

After the angle S is determined we can calculate the depth of sinking—

$$d = R(1 - \cos S);$$

the maximum pressure under the tire

$$\text{i max.} = qd$$

and the area of contact $= FR \sin S$.

Substituting in Fig. 6 a parabolic segment for the circular one we can say that the center of soil resistance is $\frac{3}{8}TR \sin S$ ahead of the axle. Consequently,

$$tW_1 \times R = W_1 \tfrac{3}{8} R \sin S$$

hence

$$t = \tfrac{3}{8}S \quad \ldots\ldots (51)$$

or

$$t = \tfrac{3}{4}\left(\frac{S}{2}\right),$$

in which $S/2$ is the slope of the chord.

Finally we get

$$t = \tfrac{3}{8}\left[\frac{12W_1}{qFD^2}\right]^{\frac{1}{3}} \text{ lb.} \quad \ldots\ldots (52)$$

The above equation does not take into account the action of the lugs, which, of course, increases the ground resistance considerably.

We thus arrive at the conclusion that a wider face of wheel gives less ground resistance. This conclusion, however, does not hold when the soil is muddy, sloppy and sticky on the surface but firm underneath; when deep mud is adhering to the wheels; when the soil surface is covered with deep, loose dust. The rolling resistance decreases more rapidly with increasing diameter than with increasing face of wheel.

Lug Dimensions

When determining the face of the driving wheels we must take due account of the necessary face dimensions of lugs or spurs. The action of lugs on the ground is similar to that of a pinion and rack. We may assume that only one lug is in mesh at a time, because setting the lugs too close would prevent self-cleaning in the softer soils. The pressure against the face of the lugs at a definite drawbar pull (for 2 driving wheels) can be calculated by means of the equation

$$P = 2F_l \times m \times j \quad \ldots\ldots (53)$$

where P is the drawbar pull for the two driving wheels; F_l, the length of the lug in in.; m, the depth of the lug and j the mean pressure against the face of the lug. Transposed this gives:

$$j = \frac{P}{2F_l m} \text{ lb. per sq. in.} \quad \ldots\ldots (54)$$

This pressure should not exceed 60 lb. per sq. in., as otherwise an enormous slippage and a large proportional loss of power must be expected. At the same time, however, the depth m of the lugs is limited, because the efficiency of the driving wheels is greatly lessened when m is too great. For wheels of 48-in. diameter it would not exceed 3 in.

Example: What is the pressure against the face of the lugs when $P = 3000$ lb. and $F_l = 12$ in.

Solution:

$$j = \frac{3000}{2 \times 12 \times 3} = 42 \text{ lb.}$$

The amount of traction obtainable depends upon the weight carried on the driving wheels, the size, shape, sharpness and number of lugs, the diameter and width of the driving wheels, the weather conditions and the cohesion of the soil.

Generally speaking, the greater the required traction the more weight there must be on the drivers in order to force the lugs into the ground. When the pull becomes excessive in proportion to the weight, the driving wheels start to slip considerably, the efficiency of the machine becomes very low and there is danger that the machine will stall.

When a wheel equipped with lugs rolls over the ground, the lugs being driven into the soil, the maximum resistance against the face of the lugs depends on the shearing resistance of the soil. The force of cohesion holds the particles of earth together so they resist separation. This cohesion force varies with the quality of soil, being greater in clay and smaller in ordinary soil. When the ground is plowed or otherwise cultivated its cohesion is entirely destroyed and can be regained only after a certain time and when the ground has been wetted.

Resistance

The resistance also depends on the friction of the earth. The cohesive force of the soil should be considered as active only when the ground has not been cultivated within a certain length of time, whereas the force of friction exists always. The friction between the steel tire of a drive wheel and the ground would not amount to much if the wheel were not equipped with lugs. But when the drive wheel is provided with lugs we have to consider friction of earth on earth and not friction of the wheel tire on earth. According to Rankine the coefficients of friction and angles of repose are:

Kind of Soil	Angle of Repose	Friction Coefficient
Earth on earth	14-45 deg.	0.25-1.00
Earth on earth, dry sand, clay and mixed earth	21-37 deg.	0.38-0.75
Earth on earth, damp clay	45 deg.	1.00
Earth on earth, wet clay	17 deg.	0.31
Earth on earth, shingle and gravel	39-48 deg.	0.81

From the above we may derive the following approximate values:

For vegetable soils, angle of repose, 40-41 deg., and coefficient of friction 0.83-0.87; for clay soils, angle of repose, 42-44 deg., coefficient of friction 0.90-0.97, the average being about 0.9.

The combined friction and shearing resistance might result in obtaining a greater traction or pull than the weight of the tractor. But in order to keep on the safe side the maximum drawbar pull according to the foregoing computations ought to be $P = 0.9W$ at the plowing speed.

Road Work

There are not many data available which would indicate how much drawbar pull can be safely expected from a tractor of a certain weight on different kinds of roads and under various conditions. We may say, however, that about two-thirds of the total weight can be obtained on country road if the tractor is equipped with proper lugs. This naturally varies with the weather, road conditions etc.

$$P_r = \tfrac{2}{3}W \text{ lb.} \quad (55)$$

where P_r is the available drawbar pull on the road.

The tractive effort or ground resistance of country roads varies from 7 per cent to 12 per cent, the average being 10 per cent. Allowing another 10 per cent as a reserve for grades, we can estimate the available drawbar pull of any given tractor on the road.

$$P_r = (t + g)W_h \quad (56)$$

Taking the ground resistance at 0.10 and the grade resistance at 0.10, we have for the necessary tractive effort to pull the total load W_h on the road:

$$P_r = 0.20W_h \quad (57)$$

or

$$W_h = 5P_r \quad (58)$$

and, as we estimated the maximum of pull to be two thirds of the total weight of the tractor, by substituting for P_r its value in equation (55) we obtain:

$$W_h = 5 \times \tfrac{2}{3}W_t$$
$$W_h = 3.33W_t \quad (59)$$

In other words, on country roads with grades up to 10 per cent the tractor is capable of hauling 3.33 times its own weight.

Longitudinal Weight Distribution

As already mentioned, the greater part of the traction or grip is obtained by friction of the soil particles. Hence we may say that the traction depends on the amount of pressure developed by the driving wheels, or, in other words, on the amount of weight carried on the driving wheels. To obtain the maximum amount of traction the designer will naturally endeavor to have as much weight on the drivers as possible, leaving on the steering wheels only enough weight to secure proper steering. In Figs. 7 and 8, A represents the tread; H, the wheelbase; C_g, the center of gravity; a, the distance of C_g from the rear axle in in.; c, the height of C_g from the ground in in.; e, the eccentricity of the drawbar in in.; h, the height of the drawbar in in.; W_d, the weight on the drivers at rest, and W_f, the weight on the steering wheels at rest.

The total weight W of the machine is supported by the front and rear wheels, and the value of W_f and W_d while standing still on the level depend on the distances a and H and can be determined by the following equation:

$$W_f H = Wa \quad (60)$$
$$W_d H = W(H - a) \quad (61)$$

Vice versa, we can calculate the necessary distance of C_g so that there will be a weight W_f on the front wheels:

$$a = \frac{W_f}{W} H \quad (62)$$

When plowing, it is usually not possible to hook the load exactly in the center between the rear wheels, because of differences in treads and in the width being plowed. Consequently, the center line of draft and that of the power do not coincide. This results in a moment Pe (see Fig. 8) tending to swing the tractor to one side. This moment Pe must be counteracted by a resistance P_s of the front wheels, which resistance depends on the weight carried on the front wheels. This counteracting moment must be at least equal to P_e, i.e.,

$$Pe = P_s H$$

Assuming that in order to obtain this resistance P_s an equal amount of weight on the front wheels is needed ($P_s = W_s$), we get,

$$Pe = W_s H \quad (63)$$

Further, from equation (62)

$$a_s = \frac{W_s}{W} H \quad (64)$$

or by substituting from equation (63) we have,

$$a_s = \frac{P}{W} e \text{ in.} \quad (65)$$

This value a_s represents the distance the center of gravity C_g must be ahead of the rear axle in order to

balance the effect of eccentricity e of the drawbar pull P alone.

Besides causing side draft, the drawbar pull has a tendency to tip the tractor over, on account of the moment Ph. From Fig. 7 we get,

$$Ph = W_p H, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (66)$$

and, further, from equation (62),

$$a_p = \frac{Ph}{W} \text{ in.}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (67)$$

where a_p is the distance of C_g necessary to balance the moment Ph alone, representing the influence of the height of drawbar pull.

When the tractor is ascending a grade of angle x, the horizontal distance of C_g from the rear support is smaller than when it is on the level. This is illustrated in Fig. 9. The horizontal distance in the inclined position is $a \cos x - c \sin x$, while on the level it was equal to a. This diminution is equal to $a_g = a - (a \cos x + c \sin x)$. But since the angle x is small we may write $a_g = c \sin x$ or

$$a_g = cg \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (68)$$

In Fig. 6 it is shown that if a wheel is rolling over soft ground it has to overcome a resistance equivalent to that of a three-fourths slope of chord $= \frac{3}{4}(S/2)$ and is not supported exactly under the rear axle but $\frac{3}{8}R \sin S$ ahead of it. According to Fig. 6 this decrease in distance C_g to the rear wheel support amounts to

$$\frac{3}{8}R \sin S = Rt \ (S \text{ small})$$

and this also must be counterbalanced by placing C_g ahead by

$$a_t = Rt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (69)$$

In order to be safe that the tractor will not tip over when the drawbar pull is applied at a certain height h above the ground, the tractor ascending a certain grade and overcoming the ground resistance t, but still will have weight enough on the front wheels to ensure proper steering when there is a certain side draft e, we must advance the center of gravity C_g such a distance as to completely counterbalance all of the above mentioned moments:

$$a = a_s + a_p + a_g + a_t$$

$$a = \frac{P}{W}e + \frac{P}{W}h + cg + Rt \ldots\ldots\ldots\ldots (70)$$

Equation (70) shows that:

1. The emergency or low speed must not be too low nor the drawbar pull P_l too high, otherwise the machine is apt to tip over and endanger the life of the operator.

2. The height of drawbar must be adjustable so the load can be hitched very low when the pull is very heavy. Otherwise the machine would either tip over or have too much weight on the front wheels when doing lighter work.

3. The center of gravity must be low to insure good weight economy on the level as well as on grades (height c small).

4. The percentage of weight carried on the front wheels, as sometimes given in catalogs, does not at all give sufficient guarantee that the machine will not tip over; the only safeguard is a definite minimum distance a between the center of gravity and the rear axle.

5. This distance a, or the location of the center of gravity, does not at all depend on the wheelbase. The longer the wheelbase the more weight there may be on the rear wheels (a being constant) and the better the weight economy.

When we are designing a new tractor we do not know the height c of C_g correctly and have to estimate same. For a preliminary calculation we can put it about equal to R; then equation (70) becomes:

$$a = \frac{P}{W}(e + h) + R(t + g) \text{ in.} \ldots\ldots\ldots (71)$$

Example: What is the minimum value of a for the following two tractors:

A has max. $P = 1.5W$
B has max. $P = W$

Other conditions are the same for both tractors, namely, $C = 6$ in., $h = 15$ in., $R = 24$ in., $t + g = 0.25$.

Solution:

$A: a = 1.5 \times 21 + 0.25 \times 24 = 37.5$ in.
$B: a = 1 \times 21 + 0.25 \times 24 = 27$ in.

The same machine which is perfectly safe with a definite pull-to-weight ratio (corresponding to a certain gear ratio) may become unstable and dangerous if the pull-to-weight ratio is increased (gear ratio too low).

What is the relative importance of the different influences on the location of the center of gravity in the case of tractor B of the above example?

Side draft a_s	= 6 in.	= 21.3%
Drawbar height a_p	= 15 in.	= 53.2%
Ground resistance a_t	= 3.6 in.	= 12.75%
Grade resistance a_g	= 3.6 in.	= 12.75%
		100%

If we consider only the influence of drawbar height, without paying attention to the other factors, as is the usual practice, the minimum safe value of a for tractor B of the above example would be 15 in., but this is only 53.2 per cent of what it should be. Thus we can see that we would make a very considerable error if we took only the drawbar height into account, instead of the sum of all the factors influencing the value of a.

Let us now discuss briefly the weight distribution in a front wheel driven tractor. It is characteristic of the front wheel drive that the more the machine pulls the less the weight resting on the front driving members. Inasmuch as most of the total weight is concentrated on the drivers (in front in this case) the machine is safe even at the heaviest pulls; but when the tractor is descending a steep hill and not pulling there is a tendency to tip over to the front. Therefore, the weight must be properly distributed with view to this condition. Consequently, for front drive (see Fig. 10)

$$a = cg \text{ in.}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (72)$$

in which a is the distance of C_g behind the front axle and g the steepest gradient which can be descended with safety.

For instance, let $c = 24$ in. and $g = 0.50$ (50% grade). Then $a = 12$ in.

When we have determined the center of gravity we can estimate the wheelbase approximately—

$$H = 2\frac{1}{2} \text{ to } 3a \ldots\ldots\ldots\ldots\ldots\ldots\ldots (73)$$

The tread A should be equal to about $2\frac{1}{4}c$ to insure the necessary lateral stability

$$A = 2\frac{1}{4}c \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (74)$$

(To be continued)

THE influence of turbulence on the explosibility of gas mixtures and on the working of gas engines was, though not overlooked, not sufficiently heeded until recent years. Experimenting on behalf of the British Association Committee on Gaseous Explosions (Dundee, 1912), Dr. Dugald Clerk observed that the rate of explosion rise increased with the number of rotations and decreased when the turbulence was damped down. An engine working normally with ignition at the end of the first compression stroke attained maximum gas pressure in 0.037 second; when ignition was effected at the end of the third compression stroke, i.e., after turbulence had subsided, maximum pressure was not attained in less than 0.092 second. Agitating the gas mixture contained in a closed cylinder by means of a fan, the late Professor Bertram Hopkinson found that with the fan at rest and at 2000 r.p.m. or 4500 r.p.m. maximum pressure was reached in 0.13 second, 0.03 second and 0.02 second.

Belgian Industry Has Big Task In Its "Comeback" Effort

Troubles of the Germans in Keeping Their Army Motor Equipment Running in Latter Days of War Show How Country Was Stripped—Labor Problems

By W. F. Bradley

WHEN the German forces first entered Belgium they made very extensive use of automobiles. Naturally, one of their first acts was to prevent any civilian traveling by automobile. This automatically shut down the factories. Many other industries, however, continued to work for a considerable time to supply civilian needs.

Large numbers of Belgian automobile owners fled in 1914, using their cars as the best means of getting away. For a number of weeks, 2000 to 3000 Belgian automobiles were parked in the public squares of the Port of Havre. Contrary to expectations, however, the Germans did not seize many private automobiles in Belgium. Where stocks existed in the factories, they took them, but the military had an objection to taking individual cars of varied makes, and the German automobile manufacturers protested against Belgian machines being used while they were in a position to produce.

As early as 1915 the effect of the blockade showed itself in a reduction in the number of German touring cars in service. While in 1914 every officer appeared to be able to get the use of a car, in 1918 the restrictions were so great that in the whole of Brussels, which was the center of the German army organization, there were not more than 50 military automobiles in service. The trolley cars were kept running, and officers used these for getting about Brussels.

The loss of rubber was a serious blow. While the Allies ran all their trucks on rubber tires, and even had automobile-hauled gun carriages rubber shod, the tire dimensions going as high as 60 by 9 in., it was a rare occurrence to see a German truck with rubber tires. Of the hundreds of abandoned or captured German trucks I examined in Belgium, not more than a dozen had rubber tires.

The stories of artificial rubber appear to be a myth. The majority of these trucks had very thick wood rims; mounted on the rim of the wheel around this was a light steel rim which made contact with the road. Another equally common method was a series of rubber blocks, each of which was set in a pair of cups mounted respectively on an inner and an outer rim. The inner rim was fixed and the rim had a certain amount of elasticity. In this case, as in the first instance, a steel rim was in contact with the road, the rubber giving a cushioning effect without being subject to friction with the road surface.

In some instances this system of rubber blocks between two steel rims was applied to touring cars. The result, however, was not at all satisfactory; speed had to be kept down to 12 miles an hour, the vibration was tremendous, and there was a decided tendency to skid.

Trucks with steel tires in contact with the road were very difficult to handle on the granite-paved roads of Belgium, and on ice or snow-covered macadam roads. As a precautionary measure, every German truck carried two large sand boxes just behind the rear wheels and under the body overhang.

Sufficient pneumatic tires were obtainable to supply the cars used by the higher staff officers at the front, but the scarcity of rubber and the impossibility of find-

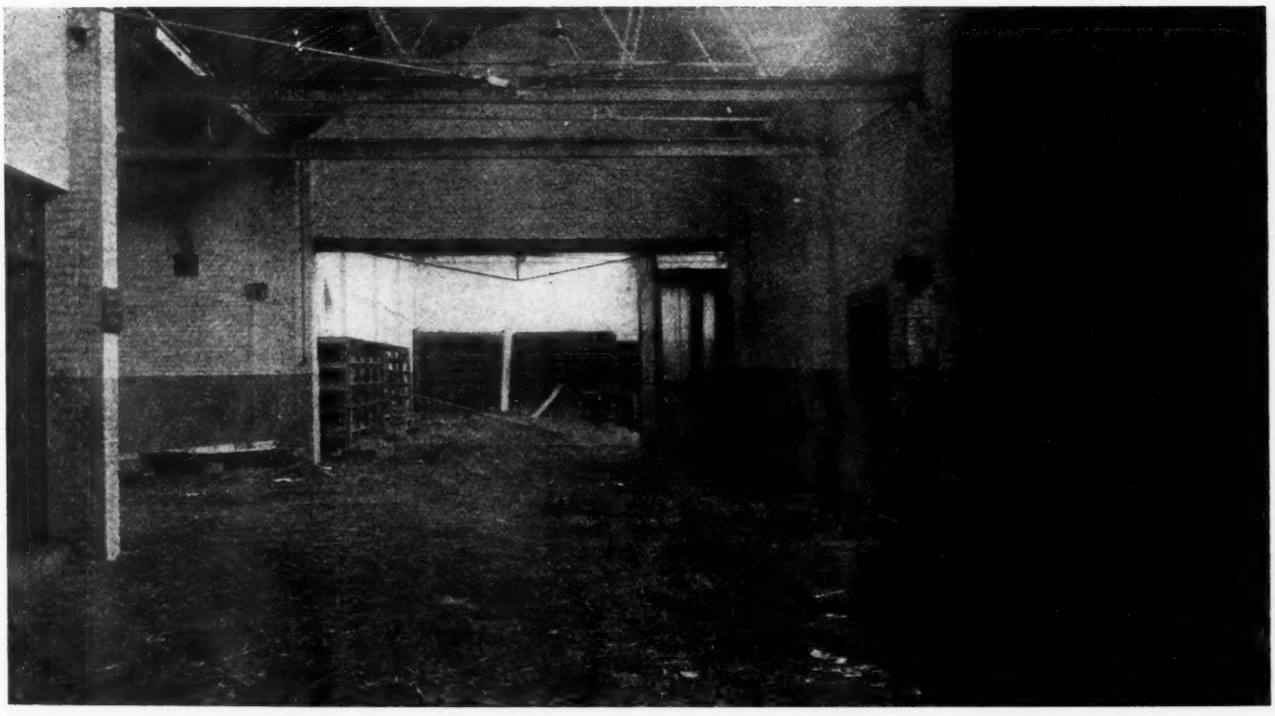
IN his two previous articles Mr. Bradley, special European correspondent of AUTOMOTIVE INDUSTRIES, told in detail of the destruction of the automotive industry in Belgium by the German army, aided by civilians. In this article he tells something of the incidental motor troubles of the invading army and of the failure of the much talked of substitutes. He also tells briefly the problems that confront the Belgian manufacturers in resuming production. As in the previous articles, the pictures taken especially for AUTOMOTIVE INDUSTRIES at the Belgian factories comprise a vital part of this story.

In this series Mr. Bradley, who went to Belgium especially for AUTOMOTIVE INDUSTRIES, draws a convincing indictment that the Germans combined war and business. There can be little doubt that much of the destruction of the Belgian plants was due to a desire to remove an after the war business competitor. This is best shown by the continued removal and destruction of machinery after the signing of the armistice was known. If you have not read the previous articles, you should get them.

—EDITOR.

Armistice Day Photographs in the Derihon Factory

The office furniture was smashed, apparently without cause



This stockroom was used as a stable after everything but a weighing machine was removed

ing a substitute for pneumatic tires restricted the use of touring cars to officers in the field.

The truck was maintained by reducing the average speed, but even with this precaution the results were so unsatisfactory that light railroads were preferred. Fortunately for the enemy, Belgium and northern France were well provided with these roads.

The impression has prevailed that Germany was well provided with gasoline. This is not borne out by automobile engineers who remained in Belgium during the occupation. The Galician and Roumanian oil fields appear to have supplied the enemy little of this fuel. At a comparatively early period restrictions were placed on automobile travel, as much with a view to economizing gasoline and oil as to save rubber.

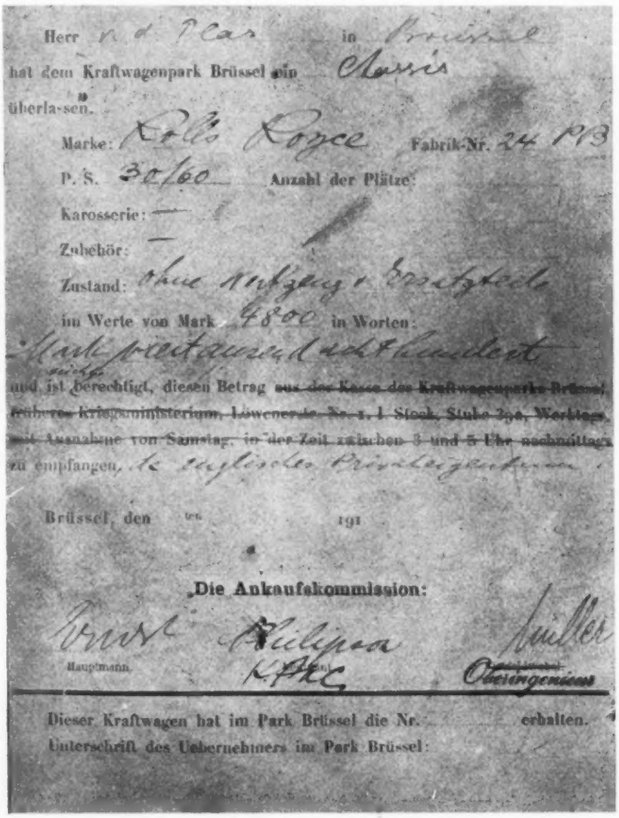
All gasoline appears to have been reserved for the air service, leaving a peculiar kind of benzol for trucks and touring cars. Although this was officially known as benzol, one engineer, who had an opportunity of using it within a few days of the departure of the Germans, stated that it was a very heavy fuel, of a yellowish tint, having a strong smell of unwholesome eggs. The consumption of this fuel was high. On the dashboard of certain 2-ton trucks the following direction was painted: "Gasoline consumption 80 liters per 100 kilometers," which is equivalent to 3 miles per American gallon.

One of the results of the war has been a serious deterioration of Belgian roads. All the macadam roads have broken down under the strain, for the German armies did as little road repair work as possible. The main roads, paved with granite blocks, were not seriously damaged during the occupation. Since the German armies left Belgium, the civilian authorities have attacked the road problem, and are widening and repairing the main roads to meet the increased traffic which is anticipated with the return to normal conditions.

The Germans made considerable use of trailers for cargo-carrying purposes, for ambulances and for kitchens. All of these were shod with steel tires. While the automobile service was reduced to the lowest possible limits, the railroads were operated to maximum capacity. At certain times there passed over the main lines a train every 5 minutes in each direction, this continuing day and night for two weeks.

When troops were being moved at this rate it was impossible to understand anything of the German plans. When fresh troops were brought from the east the trains appeared to carry an almost equal number of tired troops to the rear. In other words, the movement was so intense in each direction that nothing of the German plan could be ascertained. It was different, however, when a big offensive was in preparation, for when shells were carried to the western front the trains always returned empty.

Gasoline tractors were used for hauling big guns. These were mostly manufactured by the German Daimler, Benz, and Horsch companies. In all cases they were of the rear-wheel-drive type, with very large diameter wheels, shod with steel tires. Use was also made of big two-wheel trailers carrying a Mercedes four-cylinder engine of about 5 in. bore, which operated a winding drum, and appeared to be used exclusively for placing the big guns in position. A large number of these, in good condition, were left at the Cockerill Engineering Works.



Herr v d Plas in Brüssel
hat dem Kraftwagenpark Brüssel ein Paris
überlassen.
Marke: Rolls Royce Fabrik-Nr. 24 193
P. S. 30/60 Anzahl der Plätze:
Karosserie: —
Zubehör: —
Zustand: ohne Anhänger + Ersatzteile
im Werte von Mark 4800 in Worten:
Vier tausend achthundert
und ist berechtigt, diesen Betrag ~~aus der Kasse des Kraftwagenparks Brüssel, früheres Kriegsministerium, Löwenerstr. No. 1, 1. Stock, Stube 2a, Werktags mit Ausnahme von Samstag, in der Zeit zwischen 3 und 5 Uhr nachmittags~~ zu empfangen, d. zuständigen Privatbeamten
Brüssel, den ten 191
Die Ankaufskommission:
Hauptmann Oberingenieur

Dieser Kraftwagen hat im Park Brüssel die Nr. erhalten.
Unterschrift des Uebernehmers im Park Brüssel:

Receipt given by the Germans for a new Rolls-Royce chassis requisitioned by them at the Van den Plass body works. They allowed 4800 *marks (approximately* $1,200). *The pre-war value was* $6,000 *and during the war rose to* $9,000

The Belgian manufacturers have before them a big problem, which they are pluckily undertaking. The destroyed plants are only a part of this task.

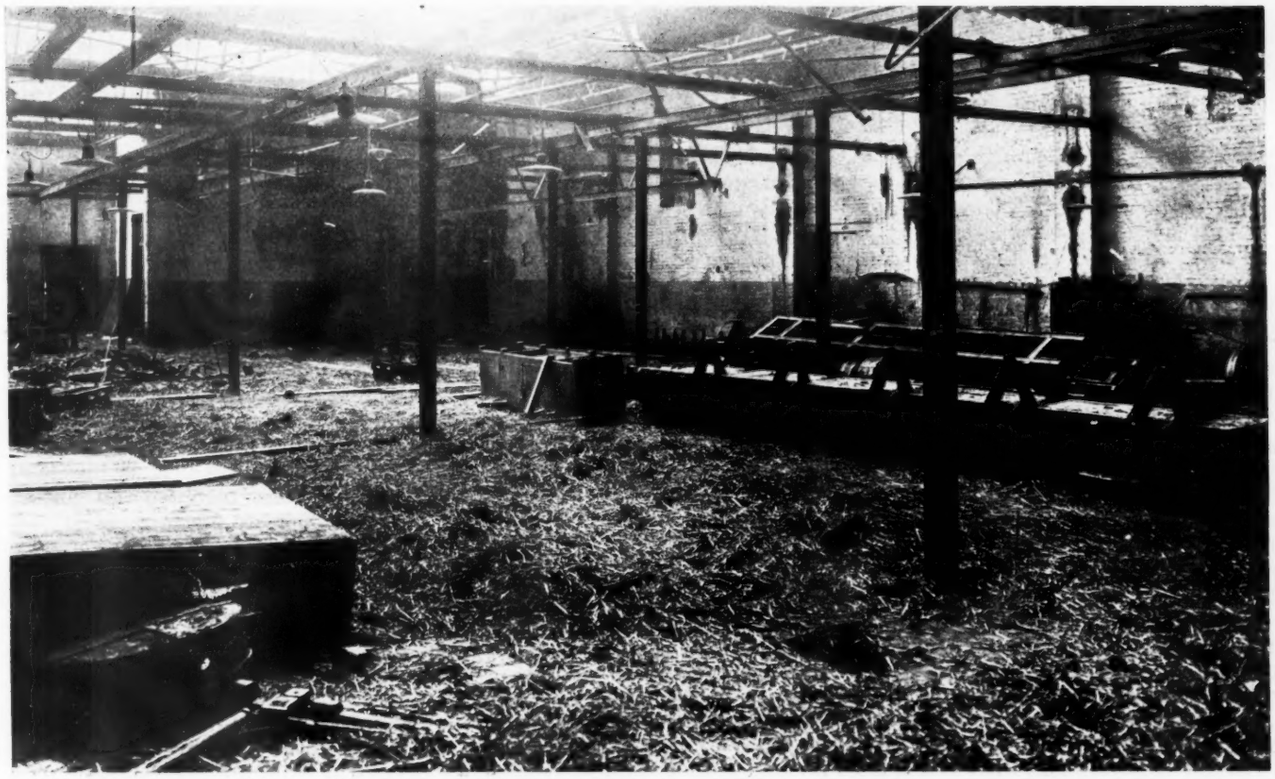
Labor conditions in Belgium are in a complex condition as the result of the war. Idleness is always demoralizing, even if adopted to hinder or injure an enemy. Belgian workpeople who have been living on 40 cents a day for 4 years, paying no rent, drawing free soup and rations, stealing from the Germans whenever possible and glorying in the action, are obviously not better for these practices. On the other hand, numbers escaped to England, where they earned high wages and enjoyed better working conditions than ever before in their lives.

These form the two extremes: the men who have been spoiled by prosperity in England and those who have been demoralized by German severity. Between them are the more intelligent and patriotic workers who realize that it is necessary to put forth enormous efforts to return Belgium to her former position.

As in France and England, the claim has been made for an 8-hour working day or less. Even in France it is recognized that the reduction in the number of hours can only be effected by the use of labor-saving machinery and better shop methods. Directors of small French industries, in which the proportion of labor to machinery is necessarily high, claim that they are seriously handicapped in comparison with the big industries in which labor is small in proportion to machine work. Until machinery can be obtained for the Belgian factories, hand work will predominate, and because of this condition the manufacturers have opposed the demand for the 8-hour day.

A compromise has been arrived at whereby the 9-hour day will be established for 1 year.

Types of Wanton Destruction by the Germans



This was a high class machine shop. The Germans left only electric light fixtures

The Germans worked until the armistice became effective adding to this pile of scrap. Most of it was made from machinery

Air Weight and Volume Measurement

Practical Use of Venturi Meter for Quantitative Determination — Graphic Methods Shorten Process of Obtaining Results and Permit of Rapid Checking During Tests

By Don T. Hastings

THE apparatus and methods described in this article greatly facilitate the making of tests and the solution of problems in which the measurement of weight or volume of air is involved. Such problems include the determination of mixture ratios delivered by carbureters, division of total air entering a carbureter between the various intakes, volumetric efficiency of engines and the influence of changes in design in valves, valve timing, gas passages, etc., on the volumetric efficiency.

THE accurate and rapid determination of volumes and corresponding weights of air presents a most difficult problem, because of the intangible nature of the material in question and its variations with respect to temperature, pressure and humidity. The effects of these three variables on the density, or weight per cubic foot of dry air, have been carefully determined, and the results are embodied in the Smithsonian Tables; consequently, if a means is found for determining either the volume or weight of a given amount of air the other quantity can be readily computed.

There are three principal methods used commercially or in the laboratory for the measurement of air volume, namely:

A—The gasometer.
B—Orifices in thin plates.
C—The venturi meter.

Of the three the venturi meter is the most accurate—the readings given by either of the other two devices being based on an initial calibration, while those of the venturi meter depend solely on its size and proportions.

The Venturi Meter

The venturi meter is an instrument for the measurement of the quantity of liquid or gas which flows through a pipe and consists essentially of a piece of round straight pipe which is contracted for a short distance to a diameter smaller than the main part of the pipe. The decreased diameter is known as the throat, and for convenience is usually made one-half, one-third or one-fourth the diameter of the main pipe; the length of the throat is usually made equal to its diameter and it is connected to the main pipe at each end by conical sections, which for the best results should have an included angle of 5 deg. to 11 deg., the smaller angle being the best. All the inside surface should be machined smooth so that there are no shoulders to interfere with the flow. Connections for manometers or gages for determining the pressure in the pipe are made at the throat and at both up and down stream ends a short distance from the ends of the tapered sections.

About 2 yr. ago it became necessary for the writer to determine the mixture proportions furnished by a number of carbureters. Being familiar with the work done by Prof. Charles E. Lucke along similar lines in the laboratory of Columbia University, his advice was followed in designing and constructing a multiple venturi meter to measure the weight of air, while the weight of fuel was determined by means of a tank mounted on an accurate platform scale.

The general layout for the air measurements was as follows:

A Root blower driven by a variable speed electric motor was arranged to draw air either from the laboratory or from outside the building and force it into a header into which the five venturi tubes were connected. From a duplicate header at the other end of the venturi tubes the air was conducted to a large air-tight box in which the pressure was maintained within one-tenth of an inch of water of atmospheric. In addition to varying the speed of the electric motor to secure this pressure relation, the blower was provided with a by-pass and automatic regulating valve.

Arrangements were made either to place the box around the carbureter or to connect the intake of the carbureter to the box by pipe of ample diameter, depending on the nature of the test being run. Every precaution was taken to prevent leakage at any point, although as the pressure in the box was maintained at atmospheric, there was practically no chance of leakage around the box affecting the results. To insure air entering the carbureter under normal conditions, that is, from a state of rest, several baffles were provided inside the box.

The construction of the multiple venturi meter is shown in Fig. 1. Five venturi tubes, each having a ratio of throat diameter to upstream diameter of one to two, were arranged between two headers of large diameter pipe. The throat diameters from top to bottom were ¼ in., ⅜ in., ½ in., ¾ in., and 1 in. Each end of each venturi tube was connected to a piece of iron pipe whose inside diameter was approximately the same as the upstream diameter of the venturi, in order to insure smooth flow and avoid eddy currents in the instruments. Between each of these pipes and the header were inserted a tee and a quick-acting shut-off valve. In addition, the three center venturis were provided with expansion joints to facilitate the assembling and avoid strains which might possibly result in air leaks.

The purpose of the shut-off valves at the upstream ends of the pipes was to permit the use of one or more venturis at a time, as required by the amount of air to be measured. The valves at the discharge ends of the

pipes, in connection with the adjacent tees, permitted two or more measurements to be made at the same time, as, for instance, the amounts of air entering a carbureter at the main and auxiliary intakes. In this case a second large box was provided to which the auxiliary intake was connected. The pressure in the second box was regulated to atmospheric by partially closing the valve at the entrance to the venturi thus used.

The venturi tubes proper were made of non-corrosive bronze and most carefully machined, so that the sizes were exact to less than 0.001 in. The workmanship was excellent, as no difficulty was experienced in maintaining the metal to metal joints airtight. Each venturi consisted of the following: 1 throat; 2 duplicate tapered sections; 2 duplicate upstream (and downstream) sections, and 2 duplicate pipe flanges. As the result of this design the throat for the ½-in.-1-in. venturi was the same as the upstream section for the ¼-in.-½-in. venturi, and the same relation existed between other sizes. The tapered sections also were made in such lengths that two or more could be joined together in case ratios other than one to two were desired between throat and upstream sections. This made a number of duplicate units so that the parts were readily manufactured, and the resulting outfit was quite flexible.

Each throat (or upstream section) consisted of two pieces. The throat proper, which was simply a ring of the proper inside diameter and length, had a groove turned around the outside at about the center of the length. From this groove four small holes were drilled through to the inside at 90-deg. intervals. The outer piece was also a ring which was a shrink fit on the throat proper. This outer ring was provided with four tapped holes for manometer connections. In assembling the two rings the tapped holes were carefully lined up with the drilled holes, so that the latter could be readily cleaned out if necessary. This construction gave an annular chamber around the throat connected at four points to the inside of the throat, thus insuring the pressure delivered to the manometer being as truly representative of the actual average pressure in the throat as possible.

The tapered sections and pipe connections were each provided with heavy flanges drilled for four bolts. The throat and upstream sections were thus clamped solidly between the two adjacent flanged pieces, making the construction very rigid and yet easily demountable when required. The clamp bolts (or their center lines) are shown in Fig. 1 only on next to the bottom venturi for the sake of clearness.

The Manometers

Previous experience with the ordinary U-tube water manometer for determining pressures led to the decision to design and construct special single-tube manometers. Special, heavy-wall, uniform-bore glass tubing was obtained, and connected top and bottom to specially designed castings, all being mounted on suitable boards for handling. The lower casting had a horizontal internal area of about 4 sq. in., while the bore of the tube was about ⅛ in. This gave a ratio of areas of about 1 to 340, and, consequently, a drop of level in the reservoir of this fraction of the height to which the column rose in the tube. By calibrating the manometer scale to allow for this drop, direct readings of height were made possible, in place of the customary two readings to be added, as in the case of the ordinary U tube.

A screw plunger for adjusting the level to zero of the scale was provided in the lower casting, similar to that found on barometers. The lower casting was also provided with a suitable drain cock, and a needle valve connection between the reservoir and the water column. Partially closing this valve assisted materially in steadying the height of the water column in case the pressure fluctuated slightly. At the same time it did not restrict the passage sufficiently to render the readings inaccurate.

The pressure connection to the reservoir was made by a special nipple and a tube carried up to the level of the top of the instruments to prevent spilling when the instrument was inclined and also to facilitate the making of connections.

The upper casting had a capacity in excess of the total volume of liquid used in the instrument to prevent over-

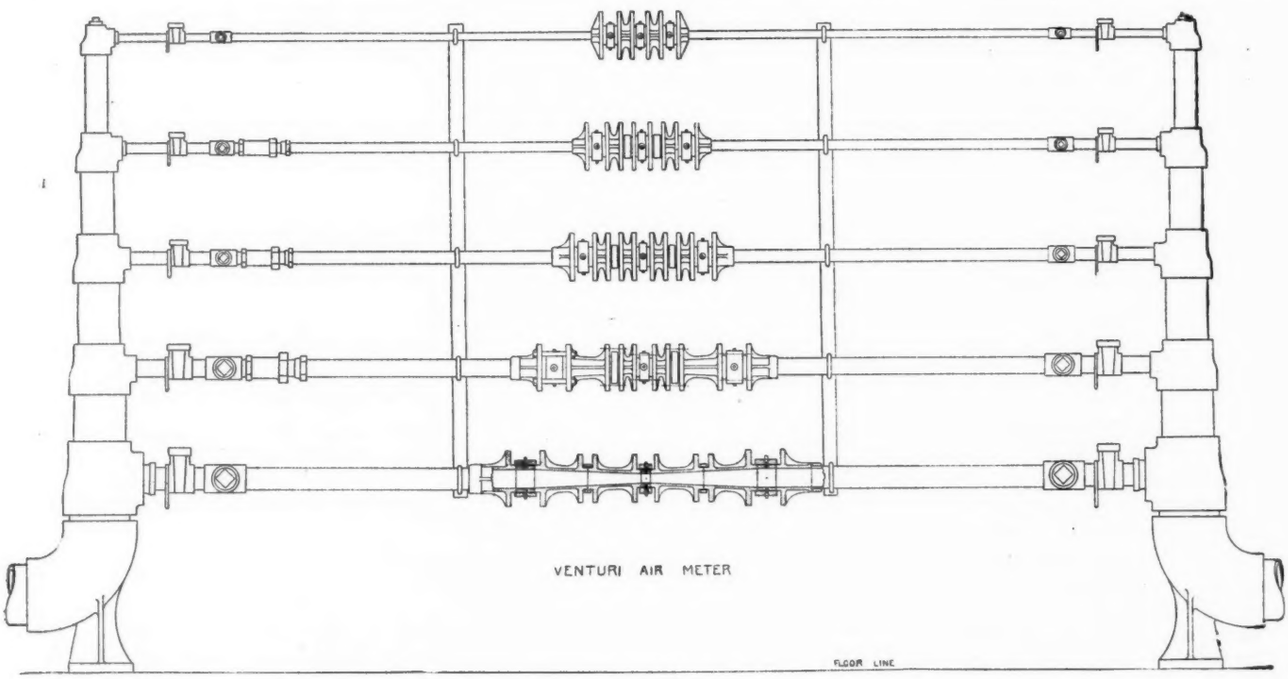


Fig. 1

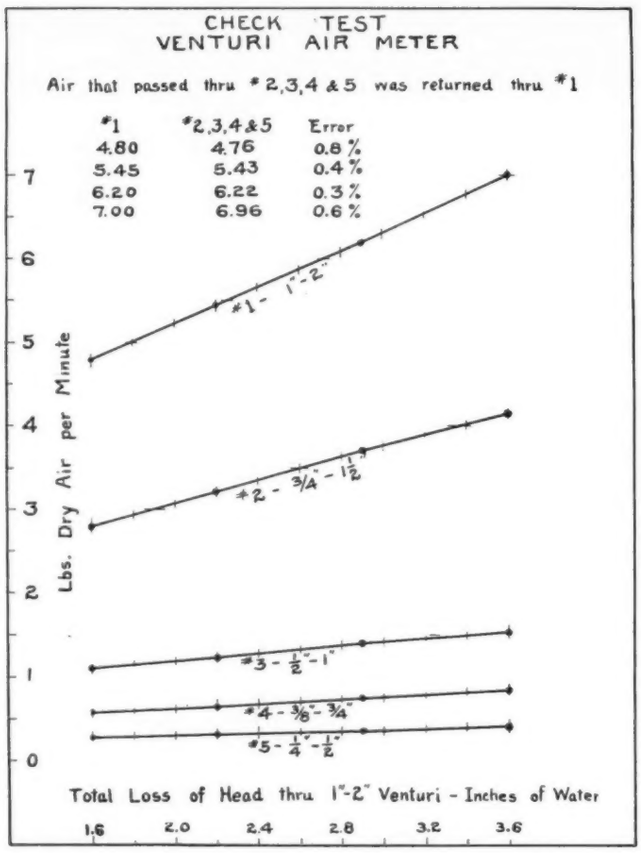

CHECK TEST
VENTURI AIR METER
Air that passed thru #2,3,4 & 5 was returned thru #1
#1 #2,3,4&5 Error
4.80 4.76 0.8 %
5.45 5.43 0.4 %
6.20 6.22 0.3 %
7.00 6.96 0.6 %
Lbs. Dry Air per Minute
#1 - 1"-2"
#2 - 3/4" - 1 1/2"
#3 - 1/2" - 1"
#4 - 3/8" - 3/4"
#5 - 1/4" - 1/2"
Total Loss of Head thru 1"-2" Venturi - Inches of Water
1.6 2.0 2.4 2.8 3.2 3.6

Fig. 2

flow in case excessive pressure was unexpectedly encountered. It was provided with a large filling plug and a suitable vent arranged to prevent the entrance of dirt. The shape of the upper casting and its connection to the top of the tube were so made that no liquid could be trapped and eventually work down to interfere with the accuracy of the readings. The vent could be readily replaced by a nipple for connection to a second source of pressure, in case it was desired to determine the difference of two pressures directly, instead of merely a pressure above atmosphere. This connection was also used if the instrument was needed as a suction gage, the vent then being through the tube leading down to the top of the lower casting.

Iron castings were used in the manometers, as they were sometimes used with mercury instead of water as the liquid. Brass would ordinarily be the better material where water only was to be used, but is impossible with mercury, due to the alloying action. No trouble was experienced with the cast iron in the water manometers, it merely being necessary to drain and rinse the instruments occasionally as the water became fouled with rust.

To insure the maintenance of atmospheric pressure in the box surrounding the carbureter a differential or inclined tube manometer was used. This is an ordinary manometer with the tube set at an acute angle with the horizontal instead of vertical. The result is to increase the movement of the liquid for a given vertical rise, permitting more accurate readings of small pressure differences. If the tube is set at 30 deg. with the horizontal the travel of the liquid along the tube is twice the vertical rise, while smaller angles give proportionately greater ratios.

As soon as the meter and blower were installed and all air leaks at pipe joints, valves, etc., eliminated, a check was made of the instrument by closing the end of the discharge header and the inlet valve to the largest venturi and removing the plug from the tee close to this valve. Air was then forced through the four smaller venturi tubes, all this air, of course, being obliged to return through the largest venturi. The results obtained are shown in Fig. 2. It will be noted that the difference for each set of readings was less than 1 per cent, indicating that the instrument is sufficiently accurate for all ordinary purposes.

The test described above is, of course, not an absolute check. An accurate check of this instrument could only be made by determining the actual weight of air, which is an extremely slow and expensive process. It was considered entirely unnecessary, however, as tests made at various places in the past have shown accuracies in the neighborhood of 99.8 per cent to 99.9 per cent. Some of these tests are described in Prof. Lucke's book, "Thermo-Dynamics."

To determine the loss of head through the instrument, a test was run whose results are shown in Fig. 3. Pressure readings were taken at the downstream end as well as at the upstream end and throat. It will be noted that the pressure loss is very small, indeed, considering the amount of air and the absolute pressures involved.

Use of the Meter

In actual use the meter permitted results to be obtained very rapidly. A few sample charts of tests made are reproduced herewith. Fig. 4 shows the mixture ratios delivered by a commercial carbureter under five different conditions of throttle opening. The wide variation as the quantity of mixture increases is, of course, very objectionable. This particular carbureter had an auxiliary spring-controlled valve. Adjustment of the

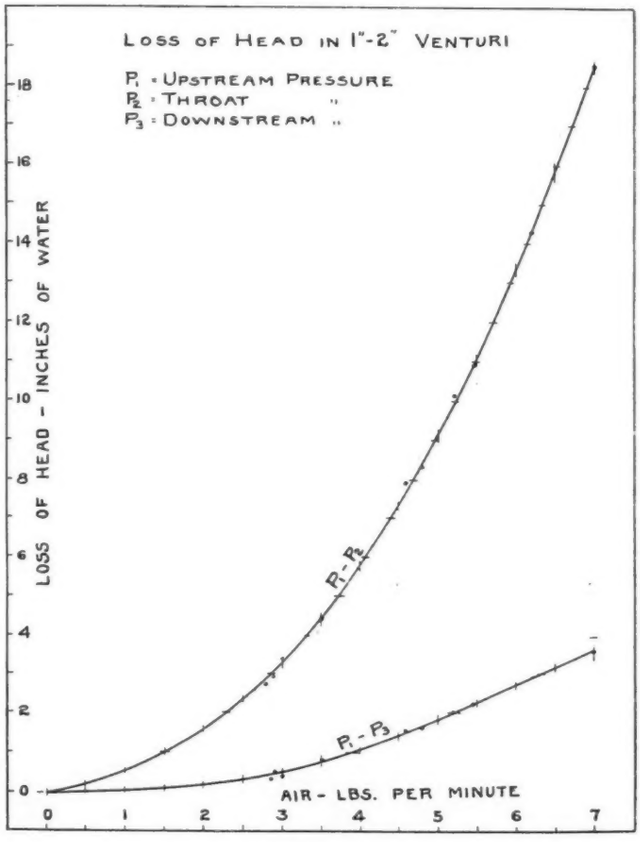

Loss of Head in 1"-2" Venturi
P1 = Upstream Pressure
P2 = Throat "
P3 = Downstream "
Loss of Head - Inches of Water
P1 - P2
P1 - P3
Air - Lbs. per Minute

Fig. 3

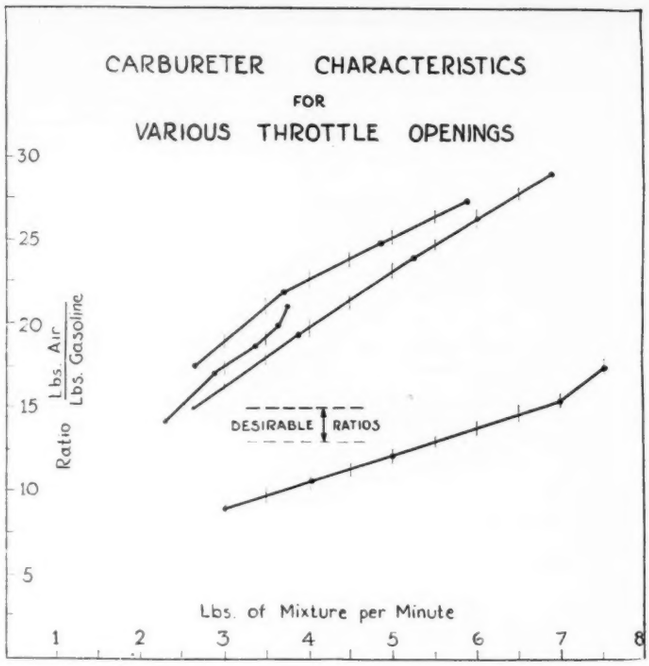


Fig. 4

spring would undoubtedly reduce the variation somewhat—the chart was selected merely to show the striking results obtained.

The test reported in Fig. 5 was made with the two pressure boxes as described above. The carbureter was of the type in which the fuel is atomized by the primary air, the quantity of fuel used being determined by the suction in the primary air passage. This chart, in connection with one like Fig. 4, furnishes an excellent guide to the changes or adjustments required to secure uniform mixture proportions throughout the speed and load range above idling. It seems to be generally accepted that a slightly richer mixture is desirable for idling, due probably to the greater dilution of the incoming mixture by the gases remaining in the cylinder.

Another very interesting test to which the venturi meter lends itself readily is the determination of volumetric efficiency of internal combustion engines, that is, the percentage of the piston displacement filled by air at atmospheric pressure under various working conditions. The amount of air is compared directly to the piston displacement, neglecting the volume of the fuel, as our present-day fuels generally enter the engine cylinders in a liquid state, even though finally subdivided by the spraying or heating in the carbureter or manifold. The volume occupied by the fuel under these conditions is relatively so small that no serious error is caused by this assumption.

The results of a test of this nature are shown in Fig. 6. A well-known truck engine, which gives general satisfaction, was tested with wide open carbureter throttle and again with the carbureter removed, the intake manifold being connected directly to the pressure box of the venturi meter. A surprising difference in the percentage of cylinder volume filled is at once apparent. It is evident that up to about 1200 r.p.m. the size and timing of the engine valves, shape and size of gas passages, etc., are about as good as it is possible to get. The one reading taken above 1200 indicates a fairly rapid falling off in efficiency at higher speeds. This is entirely immaterial, however, as the governed speed of this engine is in the neighborhood of 1050 r.p.m.

The striking thing about this test was the serious drop in volumetric efficiency when the carbureter was in place. The indications are, of course, that a larger carbureter is desirable. Before such a conclusion is accepted, however, the fuel consumption per brake horsepower hour with both carbureters should be checked up, as it is probable that the larger carbureter would give increased fuel consumption. Another factor to be carefully considered is whether the increased power is really desired. The engine is, of course, a heavy-duty one, and the power produced may be ample for the truck in which it is mounted. In any case, the increased power would undoubtedly mean shorter life and, consequently, greater repair expense and depreciation. All these factors must be taken into consideration before a change is made. Tests of this nature, however, are of considerable value in comparing different carbureters and in studying the effect of different size valves, changed valve timing, etc.

Data Required

The data which must be obtained whenever the air meter is used are shown in Fig. 7 in tabular form. This includes only the air meter data for a simple test, such as that charted in Fig. 4. The data sheet must be amplified in any particular case to include the other variables, such, for instance for Fig. 4, as fuel consumption and r.p.m.

The two temperatures and the barometer reading are used in determining the density of the air, and the barometer equivalent in inches of water, the two pressures and the two areas in determining the weight flowing per minute.

The data in connection with the density must be obtained to correspond with the air used; that is, if the air is drawn from outside the building the readings

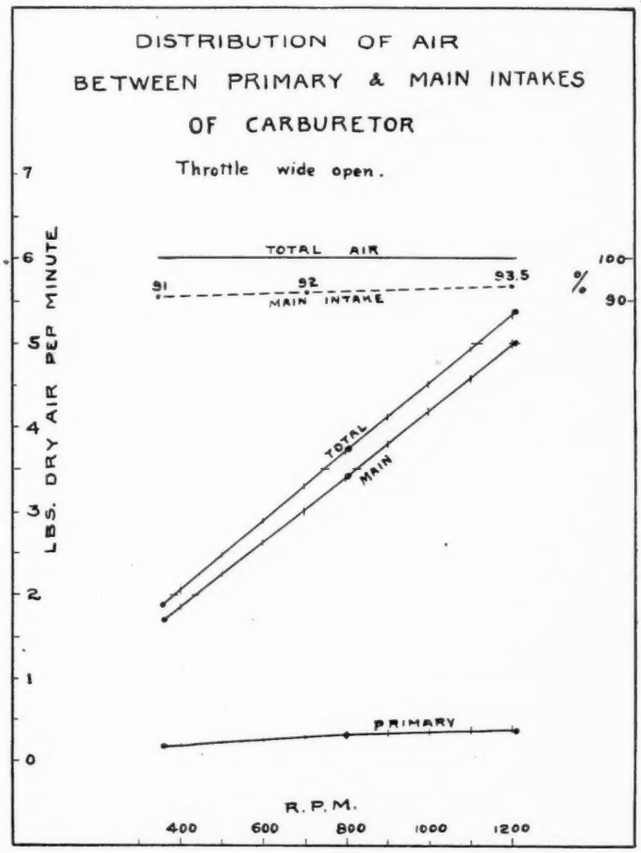


Fig. 5

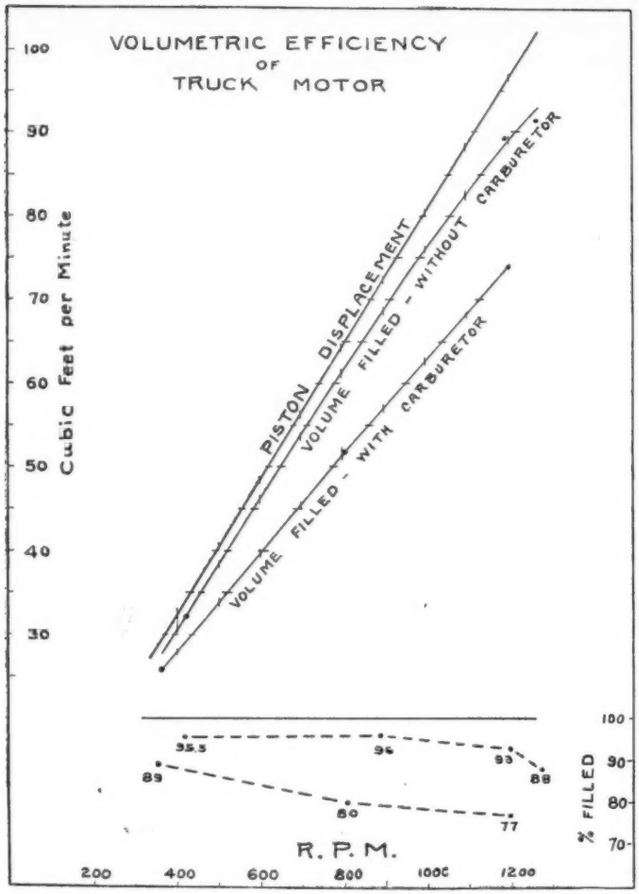


Fig. 6

should be made outside, while if air is drawn from the laboratory the readings must be made there.

The air temperature can be determined by means of any accurate Fahrenheit thermometer, readings being taken to the nearest ½ deg. The web-bulb thermometer readings are best obtained by means of a whirled sychrometer, which consists essentially of a Fahrenheit thermometer so mounted in a case that its bulb is surrounded by a cloth whose lower end is immersed in a vessel of water. This keeps the cloth around the bulb moist. The instrument is used by being swung around or to and fro at a velocity at the bulb of at least 10 ft. per second. This is the minimum velocity for accurate results—greater velocities make no appreciable difference in the readings. The temperature should be noted before starting to swing the instrument and then at short intervals until it has ceased to drop, the final temperature being recorded as t_1 in the tabular form.

Data for determining density should be obtained about each half hour at the start of a series of tests, particularly if made in a room whose temperature rises during the test, as, for instance, when an engine is being run under its own power. After three or four readings have been taken, the frequency may be decreased if conditions are found to remain substantially constant.

Computations and Charts

The computation of results, even though use is made of logarithms, is an extremely slow and laborious process, due to the complexity of the formulæ, and presents constant opportunities for errors in calculations. It has the additional disadvantage of postponing the comparison and interpretation of results until a test is completed. If one set of readings is then found to give a result widely at variance with the others, either this result must be discarded or the whole test repeated. Obviously, then, it is of great importance to be able to obtain the results immediately after a set of readings is taken. To permit this being done, the charts shown in Figs. 8, 9 and 10 were prepared. While at first glance these charts seem quite complicated, with a little practice it is possible to obtain the result of a set of readings from them in 20 to 30 sec. as compared to about ½ hr. for the straight computation.

The charts are believed to be quite accurate. In Fig. 8 the lines carrying Roman numerals correspond to the data $b = 29.5$, $t = 82$ deg. Fahr., $t = 71$ deg. Fahr. The value of d from the chart is 0.0707 lb. per cu. ft., which agrees almost exactly with the computed value 0.07066. In Fig. 9 the data being $d = 0.0795$, $P = 380$ and $P = 390$, the chart gives $d = 0.081$ as against a computed value of 0.08099, a difference of less than 0.02 per cent. Also, in Fig. 9, V from $W = 0.7$ and $d = 0.070$ shows 10 cu. ft., which is obviously correct.

The data shown in Fig. 10 by the circles is $P_1 = 396$, $P_2 = 389$, $-\frac{A_2}{A_1} = 200$, $d = 0.089$ and $A_2 =$ the area of a circle 1 in. in diameter. The chart gives a weight of 4.75 lb. per min., while the computed weight is 4.767, an error of less than 0.4 per cent.

VENTURI METER DATA SHEET

Date _____ Test Nº _____

Air Temperature t _____°F. Barometer _____" Hg.

Wet Bulb Thermometer t_1 _____°F. $t - t_1$ _____°F.

Water Equivalent of Barometer _____" H_2O

Reading Number	1	2	3	4	5
Time of Reading					
Ratio $\frac{A_2}{A_1} = \left(\frac{D_2}{D_1}\right)^2$					
Throat Diameter "					
Throat Pressure "H_2O					
P_2 - "H_2O absolute					
Upstream Pressure "H_2O					
P_1 - "H_2O absolute					
d_1-Upstream Density					
Pounds of Air per Minute					

Purpose of Test _____

Notes _____

Observers _____

Fig. 7

DENSITY OF DRY AIR.

$$d = 62.4283\left(\frac{0.00129305}{1+0.0020389(t-32)}\right)\frac{1}{29.921}\left[b-\left\{f_1-0.000367\,b(t-t_1)\left(1+\frac{t-t_1}{1571}\right)\right\}\right]$$

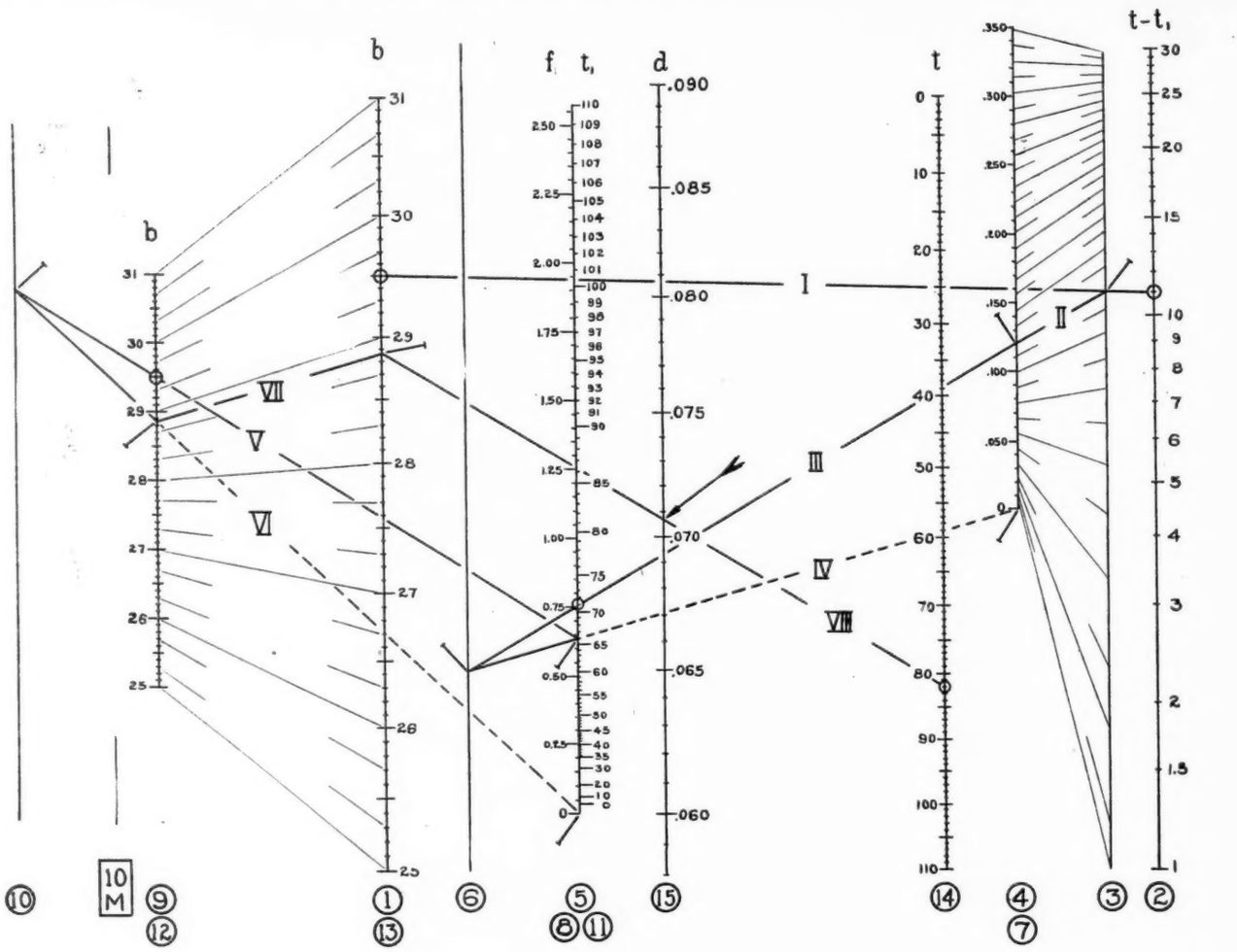


Fig. 8

SYMBOLS

d = density of dry air in pounds per cubic foot.
t = temperature of air in degrees Fahrenheit.
t_1 = temperature of wet bulb thermometer in degrees Fahrenheit.
b = height of mercury barometer in inches.
f_1 = vapor pressure in inches of mercury of saturated air at temperature t_1.

TO USE CHART

Vertical lines are numbered 1-15 in order of use.
Locate from data points on lines 1, 2, 5, 9 and 14.
Locate points on other lines by construction lines I-VIII as follows:
I through 1 and 2 locates 3.
II transfers 3 to 4.
III through 4 and 5 locates 6.
IV through 6 and zero of 7 locates 8.
V through 8 and 9 locates 10.
VI through 10 and zero of 11 locates 12.
VII transfers 12 to 13.
VIII through 13 and 14 locates 15.

NOTES

Significance of lines is as follows: 4—Smithsonian Table 41; 5—Smithsonian Table 40.
Intersection of IV and 5 shows vapor pressure on left and corresponding dew point on right.
Calibration of 14 is from Smithsonian Table 81.

MOIST AIR

To obtain density of moist air use line 10 M instead of line 10.

The density of the air where the sychrometer readings were taken is readily determined by reference to Fig. 8, complete directions for the detail use of the chart being given thereon. It may be of interest to note the significance of the several lines and their correspondence to some of the Smithsonian Tables. It must be clearly understood that the density obtained from this chart is that corresponding to atmospheric pressure. It is not the density of the air in the upstream section of the venturi which is required for use in Fig. 10.

This upstream density can be readily determined by reference to the right-hand chart of Fig. 9 and to the barometer conversion chart extending through the center of Fig. 9. The latter gives directly the height in inches absolute of a water column equivalent to the height of the mercury column of the barometer. As will be shown later, extreme accuracy in this conversion is relatively unimportant, and readings of the water column height to the nearest inch are entirely satisfactory. This quantity is P for the calculation of d_1, and is to be added to the upstream and throat manometer readings to get P_1 and P_2 for use in the right-hand chart of Fig. 9 and in Fig. 10. The value of d_1 must, of course, be greater than that of d, as the air in the venturi meter is under pressure.

After d_1 has been thus obtained it may be used in connection with the other data required in Fig. 10 to obtain the weight of air flowing per minute, complete directions being given on the chart for its use. It is perhaps advis-

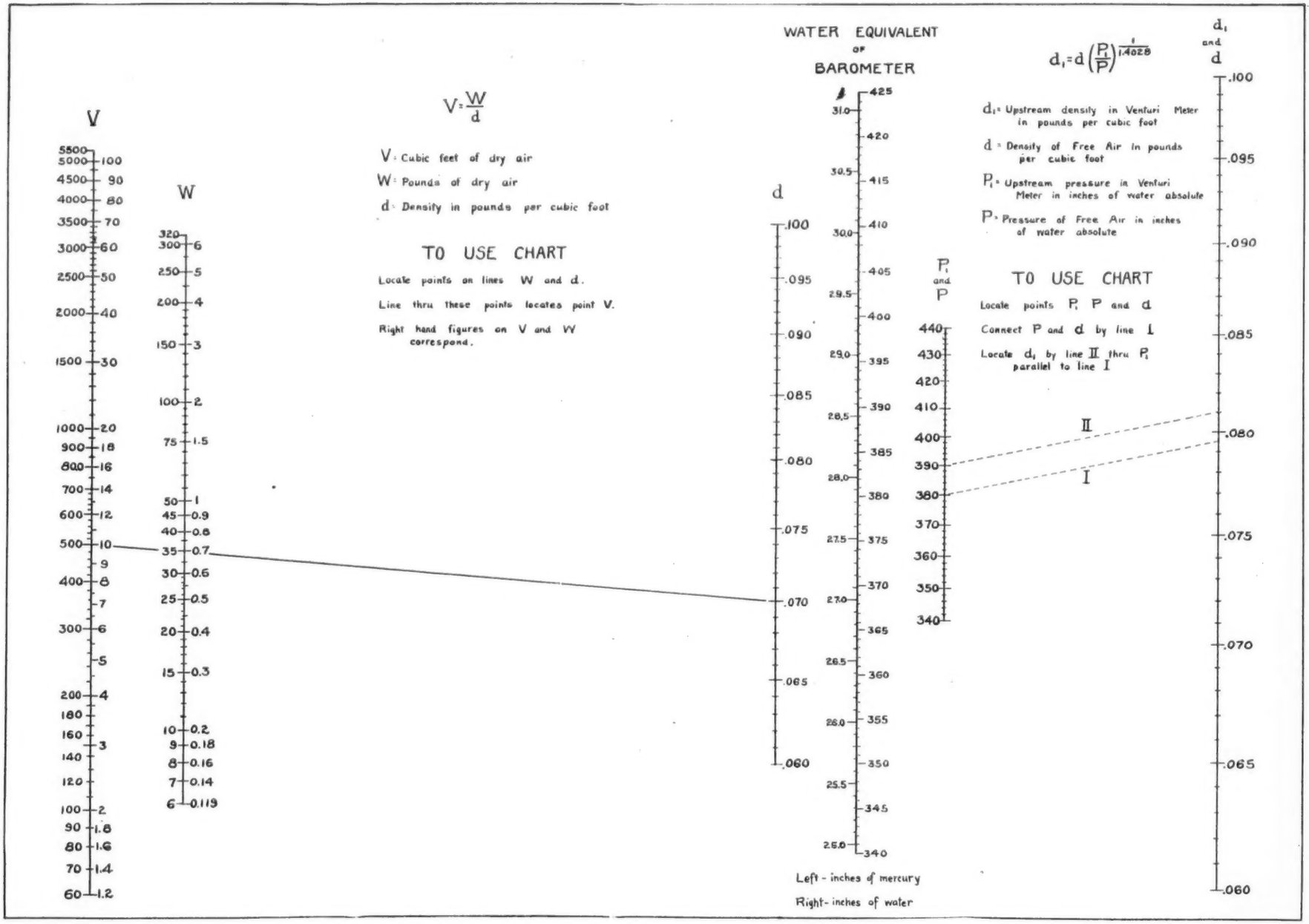

V
W
$V=\frac{W}{d}$
V = Cubic feet of dry air
W = Pounds of dry air
d = Density in pounds per cubic foot
TO USE CHART
Locate points on lines W and d.
Line thru these points locates point V.
Right hand figures on V and W correspond.
WATER EQUIVALENT OF BAROMETER
d
$d_1=d\left(\frac{P_1}{P}\right)^{\frac{1}{1.4028}}$
d_1 = Upstream density in Venturi Meter in pounds per cubic foot
d = Density of Free Air in pounds per cubic foot
P_1 = Upstream pressure in Venturi Meter in inches of water absolute
P = Pressure of Free Air in inches of water absolute
P_1 and P
TO USE CHART
Locate points P_1 P and d
Connect P and d by line I
Locate d_1 by line II thru P_1 parallel to line I
II
I
d_1 and d
Left - inches of mercury
Right - inches of water

Fig. 9

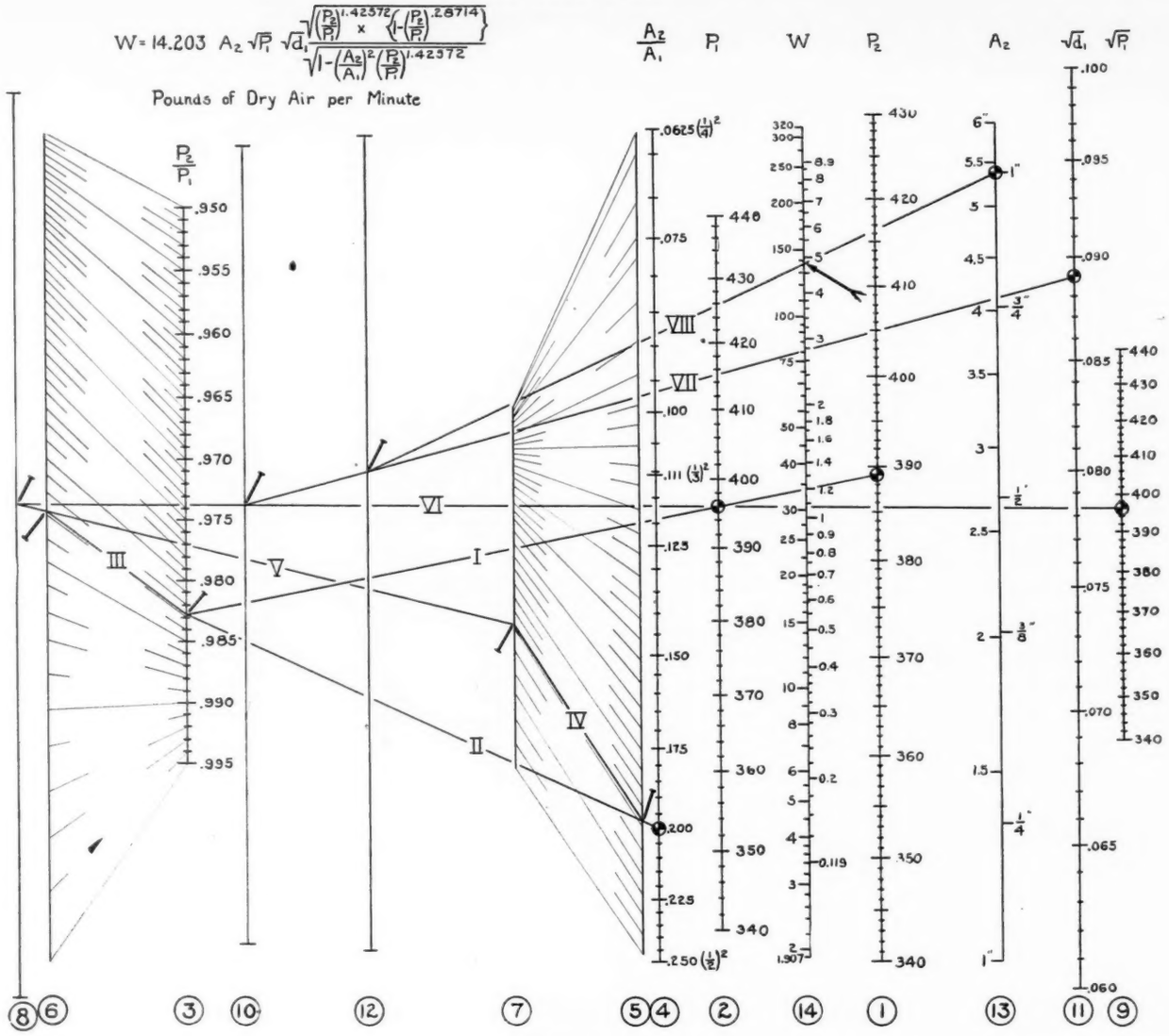


Fig. 10

SYMBOLS

W = pounds of dry air per minute.
A_1 = upstream area in square inches.
A_2 = throat area in square inches.
d_1 = upstream density in pounds per cubic foot.
P_1 = upstream pressure in inches of water absolute.
P_2 = throat pressure in inches of water absolute.
Fractions on line 4 show ratios of diameters; decimals, ratios of areas.
Figures on line 11 show densities.
Figures on line 13 show diameters.

TO USE CHART

Vertical lines are numbered 1-14 in order of use.
Locate from data points on lines 1, 2, 4, 9, 11 and 13.
Locate points on other lines by construction lines I-VIII as follows:

I through 1 and 2 locates 3.
II through 3 and 4 locates 5.
III transfers 3 to 6
IV transfers 5 to 7.
V through 6 and 7 locates 8.
VI through 8 and 9 locates 10.
VII through 10 and 11 locates 12.
VIII through 12 and 13 locates 14.

Right hand figures on 13 and 14 correspond.

able to call particular attention to the figures given on lines 4, 11 and 13. The decimals on line 4 show the ratios of the areas, while the fractions in parentheses show the ratios of diameters, the three commonest ratios only being thus expressed. Ratios nearer unity than (1/2) are inadvisable, owing to the slight pressure difference and consequent probability of error in readings, while ratios greater than (1/4) make no difference in the figure for the weight, and, consequently, the point on line 4 corresponding to the ratio (1/4) may be used for all greater ratios. It is not actually necessary to compute the areas A_1 and A_2 as the ratio only is required.

$$\frac{A_2}{A_1} = \frac{\frac{\pi}{4} D_2^2}{\frac{\pi}{4} D_1^2} = \frac{D_2^2}{D_1^2} = \left(\frac{D_2}{D_1}\right)^2$$

The square of the ratio of the diameters is much more easily computed and is the same ratio as shown above.

Line 11 is graduated proportional to the square root of d_1, but the figures given represent d_1 directly instead of its root. Line 13 is graduated in proportion to the areas of the throats, but the figures given read in inches of diameter, as this saves the labor of computing the area.

Attention is also called to the limits of the ratio $\frac{P_2}{P_1}$

These are 0.995 and 0.950, as shown by line 3. If the values obtained for P_1 and P_2 give a ratio outside of these limits, a larger or smaller venturi should be used. This illustrates again the extreme importance of obtaining the results at once after the data are recorded, to avoid the recording of unsuitable figures and permit

immediate repetition of a test, if for any reason the results are doubtful.

The left-hand chart of Fig. 9 was added to afford easy means of figuring the volume corresponding to any weight of air. It is required in case, for instance, the volumetric efficiency of an engine is being checked. Care must, of course, be exercised to select the proper value of d. In the case just mentioned it would be the value corresponding to atmospheric pressure and the temperatures t and t_1; that is, the value obtained from the chart in Fig. 8.

The Density Formula

The formula for the density of air in pounds per cubic foot given at the top of Fig. 8 is quite involved. It is based, however, on a few simple facts and its derivation is rather interesting.

The weight of a cubic centimeter of dry air at sea level in latitude 45 deg. and 32 deg. Fahr. is 0.00129305 gram. This value has been determined with great care, and is one of the accepted international standards. Under these conditions the height of the mercury barometer is 29.921 in.

Very carefully conducted experiments have proven that air expands about one-five-hundredth (0.0020389) of its volume at 32 deg. Fahr. for each degree Fahrenheit that its temperature is raised; that is, at a temperature of t deg. Fahr., its volume becomes $1 + 0.0020389\ (t - 32)$ times the volume at 32 deg. Fahr. The weight of a cubic centimeter under these conditions is decreased proportionately and becomes

$$d_t = \frac{0.00129305}{1 + 0.0020389\ (t - 32)}$$

The weight of a cubic centimeter, or, in other words, the density, also varies in direct proportion to the pressure, so that for any pressure H we have the proportion

$$\frac{d}{d_t} = \frac{H}{29.921}$$

from which

$$d = d_t \times \frac{H}{29.921}$$

and substituting our value for d_t

$$d = \frac{0.00129305}{1 + 0.0020389\ (t - 32)} \times \frac{H}{29.921}$$

For our purpose we desire the density expressed in pounds per cubic foot. There are 28,317 cu. cm. to the cubic foot and 0.0022046 lb. makes one gram. The product of these two factors is 62.4283, which, introduced in our formula, gives

$$d\ (\text{cu. ft.}) = 62.4283 \times \left[\frac{0.00129305}{1 + 0.0020389\ (t - 32)}\right] \times \frac{H}{29.921}$$

The factors 62.4283, 0.00129305 and 29.921 could, of course, be combined into a single number (0.00269787), but they are left separate in order to keep the various parts of the formula in the form used in the Smithsonian Tables. The values of the fraction in the brackets above are given for all values of t from —45 deg. Fahr. to + 140 deg. Fahr. in Table 81. By following this arrangement the checking of values given by the chart is rendered comparatively easy.

This formula is really only a variation of the familiar gas formula

$$PV = WRt$$

in which

P = absolute pressure
V = volume
W = weight
R = a constant depending on the particular gas and the units in which P, V, W and t are expressed
t = absolute temperature

From this, $\frac{PV}{Wt} = R = \frac{P_1V_1}{W_1t_1}$ and $\frac{Wt}{PV} = \frac{W_1t_1}{P_1V_1}$

Substituting the quantities d and d_1 for their equals $\frac{W}{V}$ and $\frac{W_1}{V_1}$ we get

$$\frac{dt}{P} = \frac{d_1t_1}{P_1} \text{ and } d = d_1 \times \frac{t_1}{t} \times \frac{P}{P_1}$$

Substituting our standard condition values for d_1, t_1 and P_1, dividing both numerator and denominator of the second half of the equation by t_1 we get the same result as before.

The pressure H in our formula is that due to dry air only. The actual pressure of the atmosphere as registered by the barometer is greater than the quantity H due to the presence of water vapor in the air. This aqueous vapor exerts a certain pressure e and we have the relation

$$b = H + e$$

in which b = height of barometer.

From this

$$H = b - e$$

which can be inserted in the formula for d for dry air, giving us

$$d = 62.4283 \left[\frac{0.00129305}{1 + 0.0020389\ (t - 32)}\right] \frac{b - e}{29.921}$$

The pressure e exerted by the aqueous vapor in the air has been determined to bear a relation to the barometric pressure and the temperatures as shown by the wet and dry bulb thermometers in accordance with the formula

$$e = f_1 - 0.000367b\,(t - t_1)\left(1 + \frac{t - t_1}{1571}\right)$$

in which

e = vapor pressure in inches of mercury
f_1 = vapor pressure in saturated air at temperature t_1 in inches of mercury.
b = barometric pressure in inches of mercury
t = air temperature in deg. Fahr.
t_1 = temperature by wet bulb thermometer in deg. Fahr.

The values of f_1 are tabulated for all ordinary temperatures in Smithsonian Table No. 40, and it was from this table that line 5 in Fig. 8 was plotted. The values of the quantity to be subtracted from f_1 are tabulated in Smithsonian Table No. 41—values found on line 4 of the chart correspond to this table.

Substituting the above value of e in the formula for d of dry air, we get

$$d = 62.4283 \left[\frac{0.00129305}{1 + 0.0020389\ (t - 32)}\right] \frac{1}{29.921} \left[b - \left\{f_1 - 0.000367\ (t - t_1)\left(1 + \frac{t - t_1}{1571}\right)\right\}\right]$$

This formula for the density of dry air should not be confused with that for the density of moist atmospheric air in which the weight of the moisture is included. The latter formula is very similar, differing only in that the factor 0.378 e is subtracted from b instead of the full value of e being used. This results from the fact that the density of aqueous vapor is expressed by the formula

$$d_{a.v.} = 0.622\left[\frac{0.00129305}{1 + 0.0020389\ (t—32)}\right]\frac{e}{29.921}$$

the factor 0.622 being the specific weight of the aqueous vapor relative to air. It will be seen that the formulas contain several duplicate terms, so that on adding the densities to get the density of the moist air we have

$$be + 0.622e = b—0.378e$$

in the numerator of the last fraction.

It is, of course, the density of the dry air only with which we are concerned in determining the mixture ratio delivered by a carbureter, as the moisture in the air does not enter into the combustion. On the other hand, in determining the volumetric efficiency of an engine, the density of the moist air should theoretically be used. Practically, however, the error caused by using the density of the dry air is so slight as to be negligible, consequently the chart was prepared for the density of dry air only. The change necessary to obtain moist air density consists in substituting the line 10*M* for the line 10 in locating the point of intersection of lines *V* and *VI* and the chart can be so used if desired.

Densities in Venturi Meter

The density obtained from Fig. 8 is that of air at atmospheric pressure. This quantity cannot be used in connection with the chart of Fig. 10, as the density in any one of the venturi tubes is greater than this amount, owing to the greater pressure in the tube. The compression is assumed to be adiabatic; that is, such that the air does not give up heat to or receive heat from the blower or venturi tube walls, due to the extreme rapidity of flow, and consequently the volumes are related to the pressures as follows:

$$PV^s = \text{a constant}$$

$$\text{Since } d = \frac{1}{V} \text{ we have}$$

$$\frac{P}{d^s} = \text{a constant} = \frac{P_1}{d_1^s}$$

From this,

$$\left(\frac{d_1}{d}\right)^s = \frac{P_1}{P} \text{ and } \frac{d_1}{d} = \left(\frac{P_1}{P}\right)^{\frac{1}{s}}$$

Consequently,

$$d_1 = d\left(\frac{P_1}{P}\right)^{\frac{1}{1.4028}}$$

The right-hand chart of Fig. 9 affords an easy means of determining d_1 ready for use in the chart of Fig. 10. Care must be exercised in case more than one venturi tube is used at the same time to determine the density d_1 for each tube in accordance with its upstream pressure P_1.

Water Equivalent of Barometer

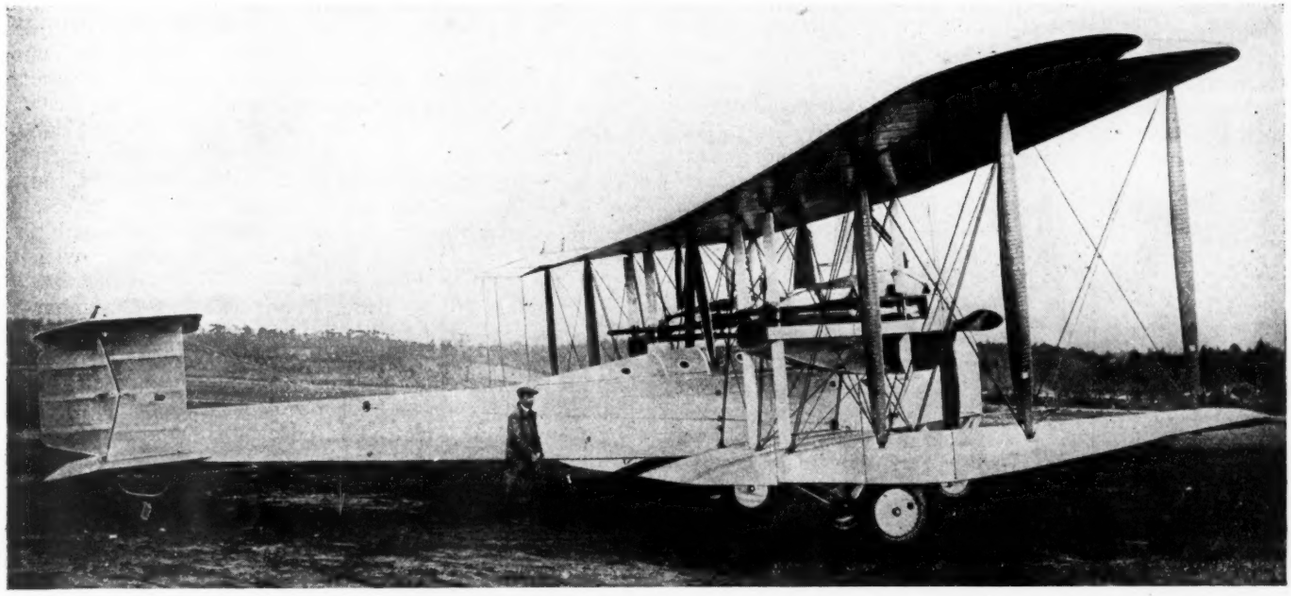
It was stated above that the exact determination of the height of a column of water equivalent in pressure to that of the barometric mercury column was relatively unimportant. This is true only because the factors into which this enters are all expressed as ratios, and, consequently, even a relatively large error affects the result by less than 0.1 per cent. For example, suppose that the equivalent of 29 in. by barometer is read as 395 in. water or as 397 in. water. Assume $P_1 = 20$ in. and $P_2 =$ 10 as read on the manometers. Our ratio of $\frac{P_2}{P_1}$ absolute becomes $\frac{405}{415}$ or $\frac{407}{417}$

These are equal respectively to 0.97590 and 0.97602, which values differ only slightly over 0.01 per cent.

The conversion chart on Fig. 9 is about correct for ordinary room temperatures. As shown above, however, no serious error will be made if the chart is used for any temperature likely to encountered.

(*To be continued*)

Vickers-Vimy Ready for the Transatlantic Flight

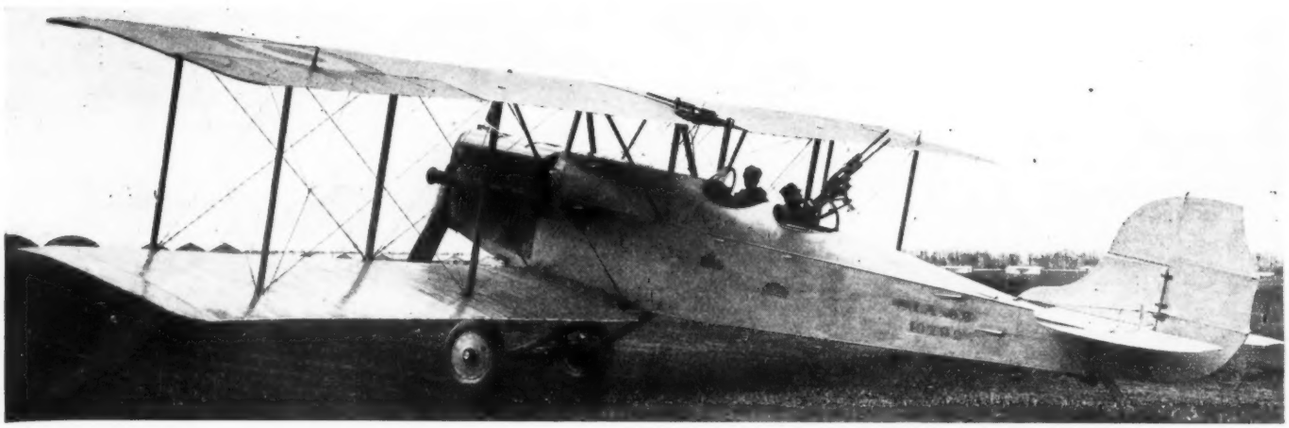


THE required 4-day notice of a probable Transatlantic flight was filed with the British Admiralty on Sunday by Captain Alcock, pilot of the Vickers-Vimy airplane at St. John's, N. F. This airplane was assembled on the starting grounds. A. W. Brown is the navigator. The plane is equipped with two standard 350-hp. Rolls-Royce engines and has a fuel capacity of 865 gal. and 50 gal. of lubricating oil. It is estimated to have a flight range of 2810 miles. The maximum speed is 100 m.p.h., but the speed for the long flight probably will be 90 m.p.h.

Fiat Plane for Transatlantic Flight

A High-Speed Machine with Single 700-Hp. Engine Designed to Make the 2000-Mile Trip in 14 Hours

By W. F. Bradley

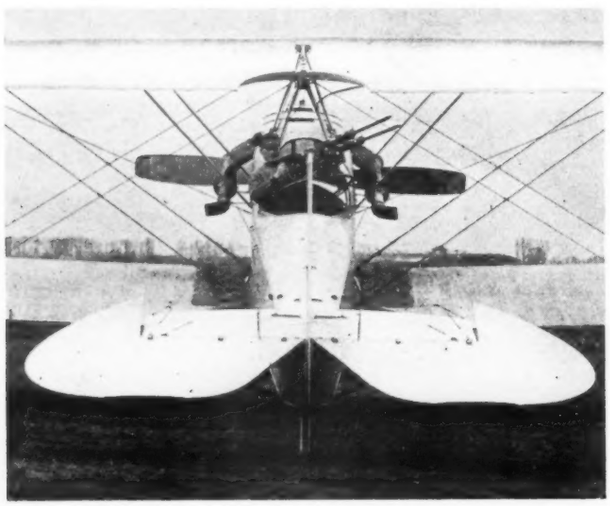


Fiat bombing and reconnoissance plane which is to make a transatlantic flight

TURIN, ITALY, May 15—Fiat is building a special airplane which will be capable of crossing the Atlantic in 14 hours, without the assistance of steamers along the line of flight, according to officials of the concern.

The Fiat machine is a biplane having an all-metal fuselage, divided into watertight compartments which will contain 660 gal. of gasoline, this being more than sufficient for the flight across the Atlantic. In case of an accident, which obliges the pilot to come down on the water, this fuselage can be emptied almost instantaneously and will then serve as a lighter capable of keeping the pilot and passengers afloat for a number of hours.

The machine is the work of Engineer Rosatelli, who believes that the only method of crossing the Atlantic is by means of a very fast, big, load-carrying airplane.



Rear view of the fuselage

As the route selected is 2000 miles in length, the Fiat machine will have to average 145 miles an hour. It is claimed that the plane will have a higher speed than this, for just before the war came to a close Fiat had produced what is officially known as the BR-biplane, which had attained a speed of 158 miles an hour with a net load of 1 ton. This speed is higher than that attained by any of the chaser planes used on the front when the war came to a close. The experience gained in the construction of the BR is being made use of in building the Atlantic machine.

As in the case of the BR, a single Fiat 12-cylinder, 700-hp. engine will be used. This is an engine which has been produced in quantities for a considerable time. It is claimed that the BR-biplane was capable of carrying a load of 1½ tons and maintaining its speed of 158 miles an hour. This machine was therefore able to drop ½ ton of explosives on any point within a radius of 300 miles. When the armistice came into effect, no bombing machine in the Allied service was capable of making a trip of this length, even if running without a load of bombs.

The pilot will be Brack-Papa, who has a number of important records to his credit, among them being the passenger-carrying height record of 23,050 ft. in 1 hr. 3 min. It is stated that the pilot and those assisting him in this undertaking have developed a scheme whereby position may be plotted while over the water and while flying at a speed of 150 miles an hour. This system has been given a practical test in several long-distance flights, notably in the 1000 miles non-stop trip from Turin to Naples and back, which was accomplished in 10 hr. 30 min.

—

THE Bergie National Spark Plug Co., Rockford, Ill., has brought out a special spark plug for tractor and stationary engines with stone insulator. The insulator is claimed to be practically unbreakable, heat-proof, oil-proof and compression-tight.

The Kessler Super-Charge Engine Developed for Automobile Purposes

Uses Four-Stroke Cycle With Ramming Charge of Excess Air—Crankcase Compression Employed

FOR several years engineers have realized that one method of increasing the mean effective pressure of engines would be by increasing the volumetric efficiency. Naturally, with this in mind, the first thought is the utilization of some outside pressure to ram an excess charge into the combustion chamber. This idea has been dormant up to the time of the war, when the necessity for securing high compression pressures at extreme altitudes brought it into prominence again.

One of the super-charge engines which received attention from the Government at that time is the product of the Kessler Motor Co. of Detroit. This engine, which has been in a state of gradual development for nearly a decade, was under test by the navy aircraft authorities and was just about to be manufactured when hostilities ceased. The engine was then developed for automobile work, and, largely owing to the impetus given to improved engine design by aviation engineers during the war, it is now receiving a great amount of consideration.

The Kessler super-charge engine operates on the ordinary four-stroke cycle. At the bottom of the intake stroke, however, the piston uncovers ports through which is forced a quantity of air, constituting the super-charge. Thus, when the piston starts to rise on the compression stroke the pressure is already above atmospheric, and it is not necessary for the crank to travel through 20 or more degrees before compression actually starts. With this added volume of air it is necessary that the ratio of the total volume to the volume of the compression chamber be considerably less in the Kessler engine than it is in the normal engine. This is readily explained by the diagram shown in Fig. 4. The figures show a normal engine with a compression ratio of 5 to 1, and the lower two diagrams show a compression ratio with a Kessler supercharge engine of 3 2/3 to 1. Both of these engines would have approximately the same initial compression of 100 lb. per sq. in. Thus, although the compression space is larger in the Kessler engine, the compression is the same, owing to the excess of air admitted.

Crankcase compression is relied upon to furnish the super charge of air. The quantity of air admitted is governed by some form of valve between the crankcase and the cylinder intake ports. The form of valve used in the latest engines is a rotary, connected with the throttle so as to automatically govern the amount of air admitted by throttle conditions. On the intake stroke the regular poppet intake valve is employed, but it closes at bottom center or very nearly at bottom center, so that there is no chance for the incoming air to blow back through the poppet intake. In fact, it is important, as will be seen, to close the intake valve early enough so that there is no disturbance of the incoming charge through the poppet valve.

The operation of the engine is readily understood from the foregoing explanation of the cycle. As the piston descends on the intake stroke it draws in what would be the normal amount of charge, and just before the bottom of the stroke the incoming charge of air from the crankcase has passed through the rotary valve. As soon as the piston uncovers the ports the pure air from the crankcase rushes in, sweeping across the head of the piston and filling the bottom of the displacement space with air. This is compressed along with the charge which came in through the poppet valve, at about the same compression as is used in the ordinary high-speed gasoline engine. Firing occurs in the usual manner and exhaust is taken care of through the usual form of poppet exhaust valve.

Referring again to Fig. 4, it is readily apparent where the gain in mean effective pressure comes in. At the bottom of Fig. 4 are shown two typical cards, one from a standard gasoline engine and the other from the Kessler. It will be seen that the expansion curve is slower to drop in the Kessler engine than it is in the standard type. Thus, the higher pressures are available through the working stroke, and particularly at points where the

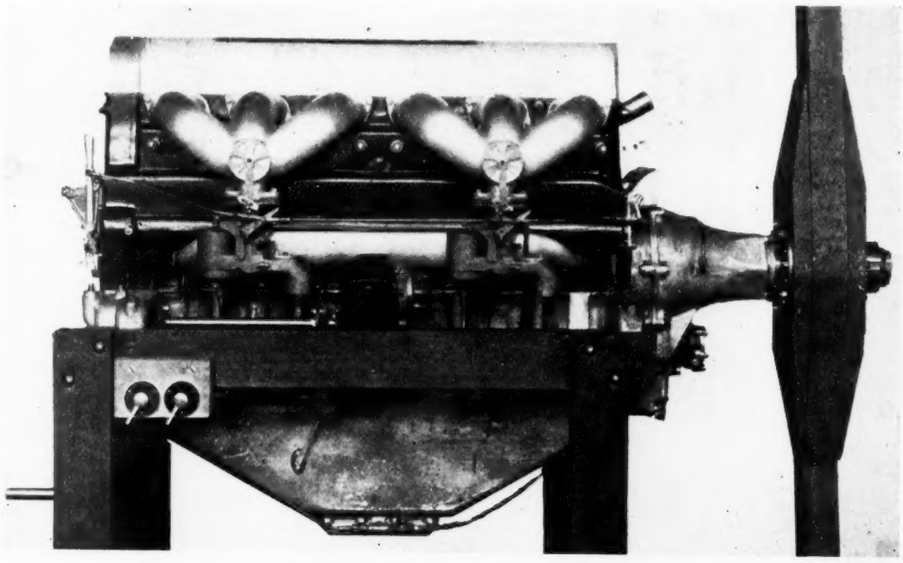


Fig. 2—Kessler aviation engine developed for the United States Navy, developing 200 hp. at 2400 r.p.m.

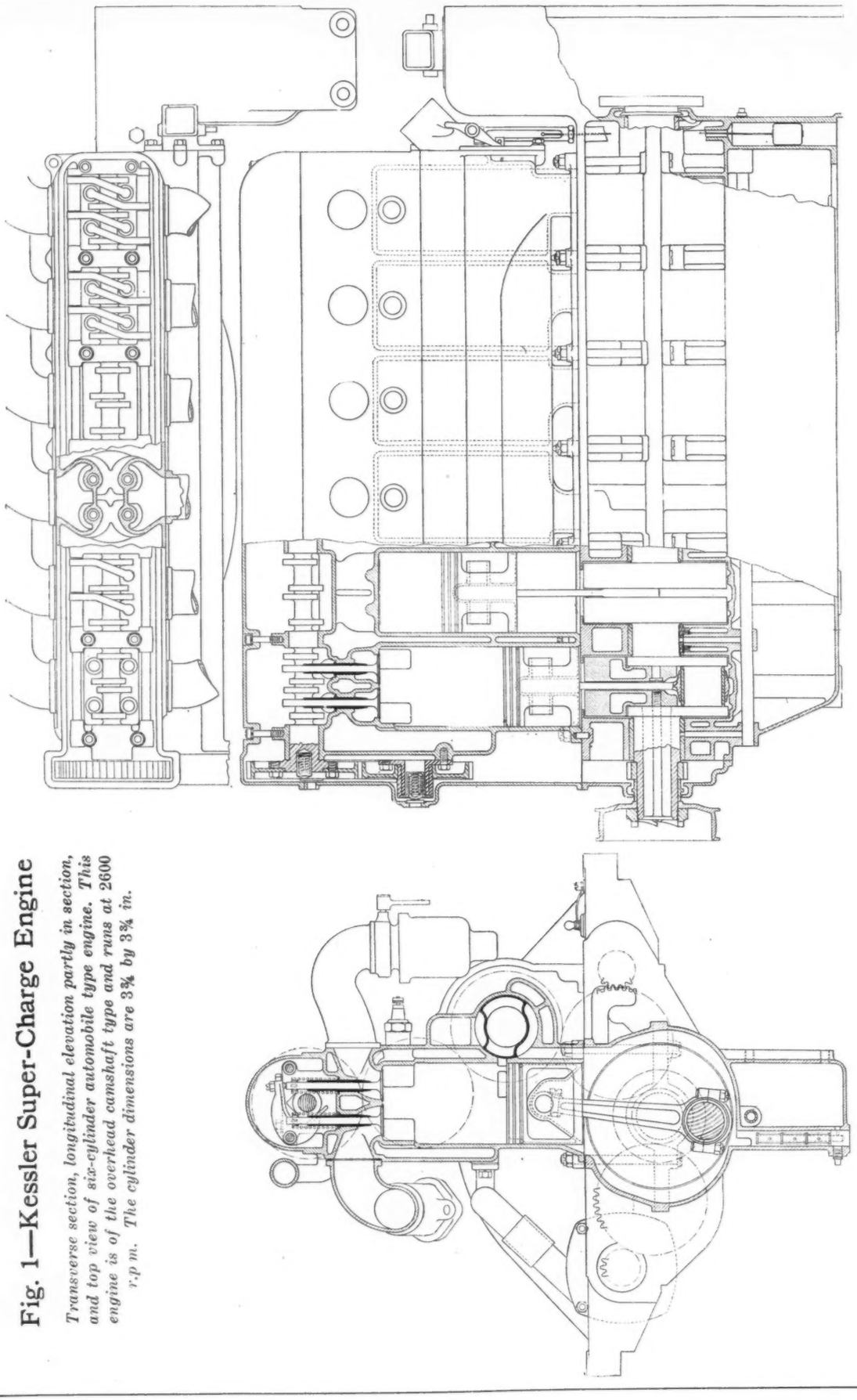


Fig. 1—Kessler Super-Charge Engine

Transverse section, longitudinal elevation partly in section, and top view of six-cylinder automobile type engine. This engine is of the overhead camshaft type and runs at 2600 r.p.m. The cylinder dimensions are 3¾ by 3¾ in.

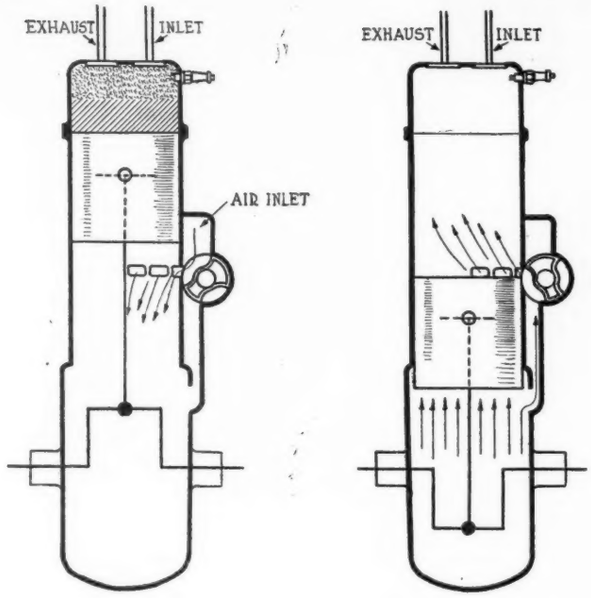


Fig. 3—Sketch showing cycle of Kessler super-charging engine and also stratification charge and cushioning effect under piston

maximum torque effort is being placed upon the cranks, due to their approach to the 90-deg. position.

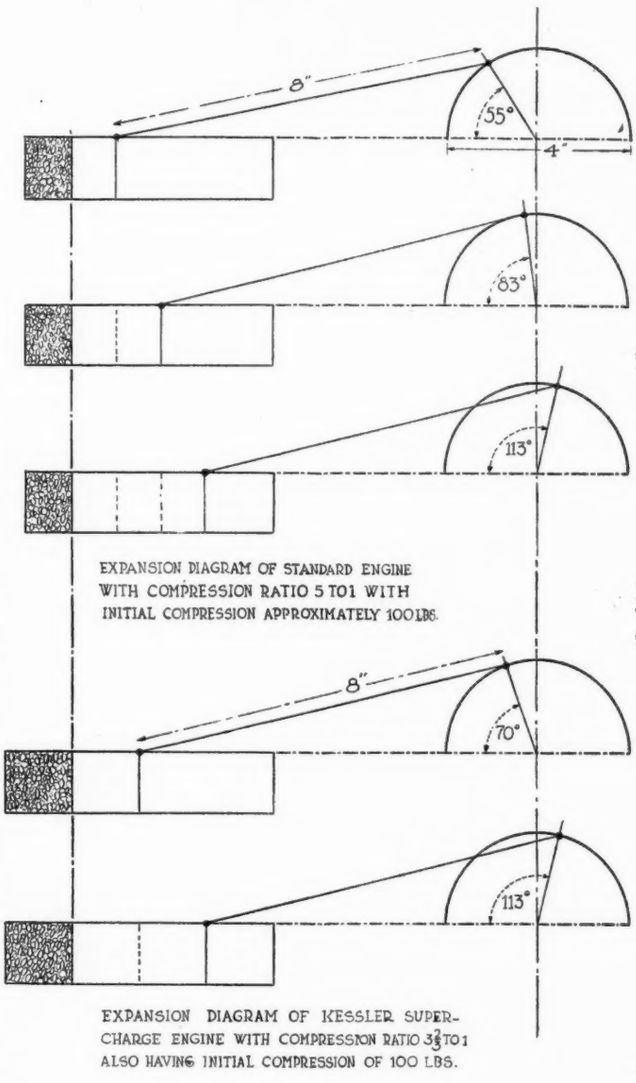
In the upper part of Fig. 4 are illustrated three stages in the expansion of the charge in a typical gasoline engine with 5 to 1 compression ratio. The first expansion, to the point where the volume swept through by the piston is equal to the compression chamber volume, corresponds to a crank travel of 55 deg. After the second expansion, or when the volume swept through by the piston is equal to twice the combustion chamber volume, the crank has passed through 83 deg., and after the third expansion (three times compression chamber volume) it has passed through 113 deg. In the Kessler engine, owing to the greater volume of the compression chamber, the crank has passed through 70 deg. after the first expansion stage and 113 deg. after the second. Thus, with a greater volume of gas available on each working stroke, the expansion curve is bound to be higher throughout, and this accounts for the increased mean effective pressure.

Naturally, the first inquiry likely to be made regarding a cycle of this sort is whether or not the air dilution does not simply tend to thin out the mixture, but to this the inventors reply that they have evidence of marked stratification in the compression space; that this can be clearly shown by varying the location of the spark plugs. If the plugs are high, near the inlet stream from the poppet valves, perfect ignition results. On the other hand, if they are placed low where they would be in the path of the incoming air from the super-charging ports, either no ignition or very faulty ignition results, indicating that conditions of the charge are different in different parts of the cylinder. It is the claim of the Kessler company that this air drawn in through the ports at the bottom of the stroke lies on top of the piston and is carried up with it.

The explosion takes place in the upper part of the compression chamber and the air in the lower part absorbs heat from the explosion and then gives this heat up again during expansion. The resulting terminal pressure is somewhat higher than in the conventional engine, owing to the fact that it is not possible to get back all of the heat energy imparted to the excess air. A marked cushioning effect of the explosion is claimed, due to the presence of the excess air on top of the piston, which tends to retard the pressure peak. The cushioning effect is also claimed to reduce to a marked extent any tendency for a high compression engine to pound, as the blow on top of the piston is stated to be remarkably softened due to this volume of air.* A cushioning effect is also claimed for the crankcase compression, and it is said that at certain speeds the bearings automatically float, due to the relieving cushion of the air in the crankcase.

A staff representative of AUTOMOTIVE INDUSTRIES has

*This statement hardly agrees with the two indicator diagrams shown, of the standard and Kessler engines respectively, which show equal explosion pressures.—EDITOR.



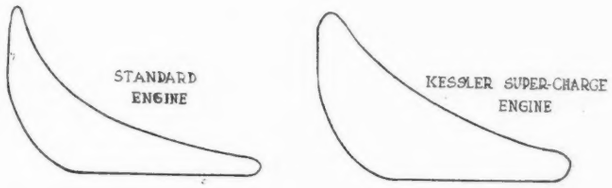


Fig. 4—Charts showing comparison of expansion diagrams of Kessler and standard engines

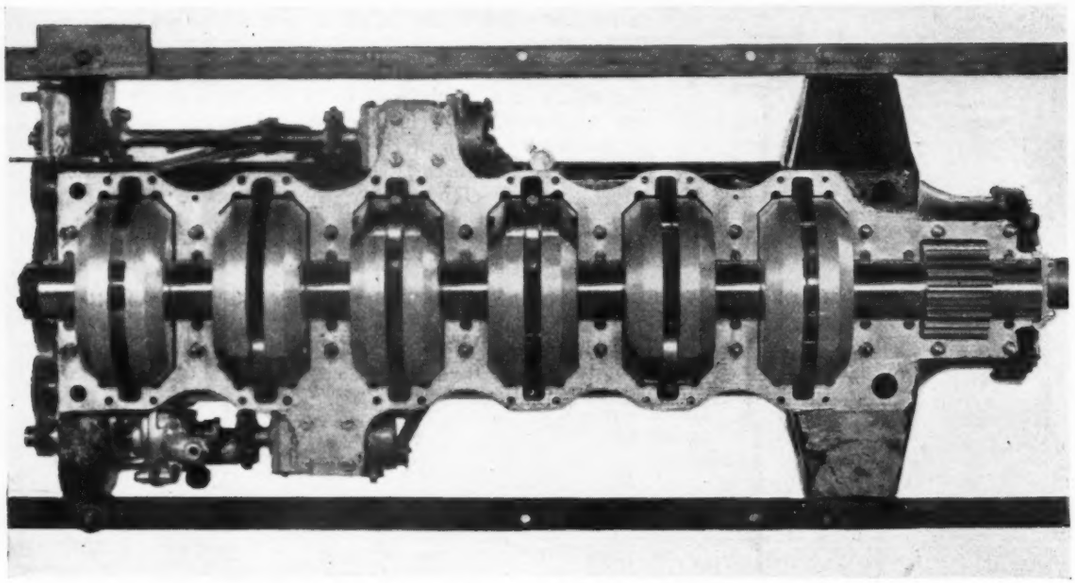


Fig. 5—Left—Counter-balanced crankshaft mounted in crankcase. Fig. 6—Right—Piston and connecting rod

seen at the Kessler plant a car with a four-cylinder Kessler engine mounted in it, this engine having made over 60,000 miles without having been taken down. The engine is in bad condition, and inasmuch as the supercharged air was drawn through an opening in the front end of the engine and the front of the engine itself is caked with the gritty accumulation of 5 years, it is safe to imagine that the inside of the engine is in extremely bad condition. The air intake for the super-charging air is controlled by a butterfly in this particular engine, and there is no screening or other device in front of it. Yet, in spite of this, the acceleration of the engine is remarkable, and, although the engine is a four, it compares favorably with multi-cylinder engines in this respect.

Claim Carbon Knocks Impossible

This engine is used by the Kessler company as evidence to support the claim that bearing loads are exceptionally light due to the balance secured by the air cushion in the crankcase and the air cushion above the piston at the time of explosion. The excess of air tends to act as a carbon cleaner also, so that carbon knocks are said to be impossible with this type of engine.

There are a great many structural designs possible with this cycle. It is nothing more than an ordinary type of engine plus the excess air charge admitted at the bottom of the suction stroke. It is quite apparent that the amount of air admitted must depend to some extent on the amount of charge drawn in, and consequently at reduced throttle openings the amount of air would be less than at full throttle opening. This is taken care of by the inter-connection of the valve controlling the air and the throttle. In the case of the rotary valve, the throttle does not control the opening and closing of the valve, but simply times it by means of a spiral guide, advancing or retarding the functions of the valve.

15-Pound Pressure Found Best

When idling only a very moderate amount of excess air is admitted, or none at all, but as soon as the load is increased the amount of air admitted is materially augmented, until at full open throttle the full period during which the ports are open is utilized in forcing in the air under a pressure of some 15 lb. This pressure has been experimented with and it has been found that best results are obtained with about that amount. A simple experiment with an ordinary engine will readily show what effect this has.

For instance, if a man were to blow into the petcock on top of the cylinder during the intake stroke or immediately after the intake were closed, and while the pressure was still at atmospheric in the cylinder, he would find an enormous increase in the final compression pressure. For this reason, with this amount of pressure put in the combustion chamber of the Kessler engine, it is possible to use a much greater volume of compression chamber and still have the same initial compression. Furthermore, as experiment with the old engine in the car has shown, slight leaks around the piston or past the valves do not reduce the power output to the same extent as in an ordinary engine.

The net result of this gain in mean effective pressure is the production of a much higher power output per

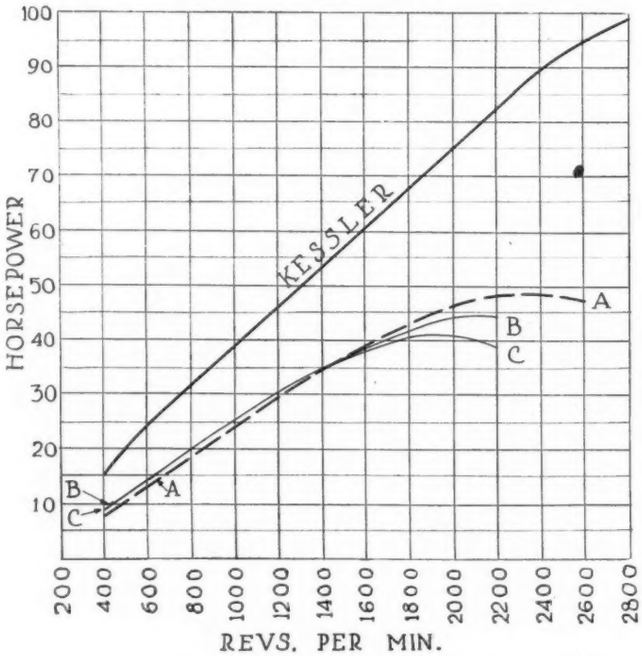


Fig. 7—Horsepower curves of Kessler and other standard engines, reduced to 247 cu. in. piston displacement

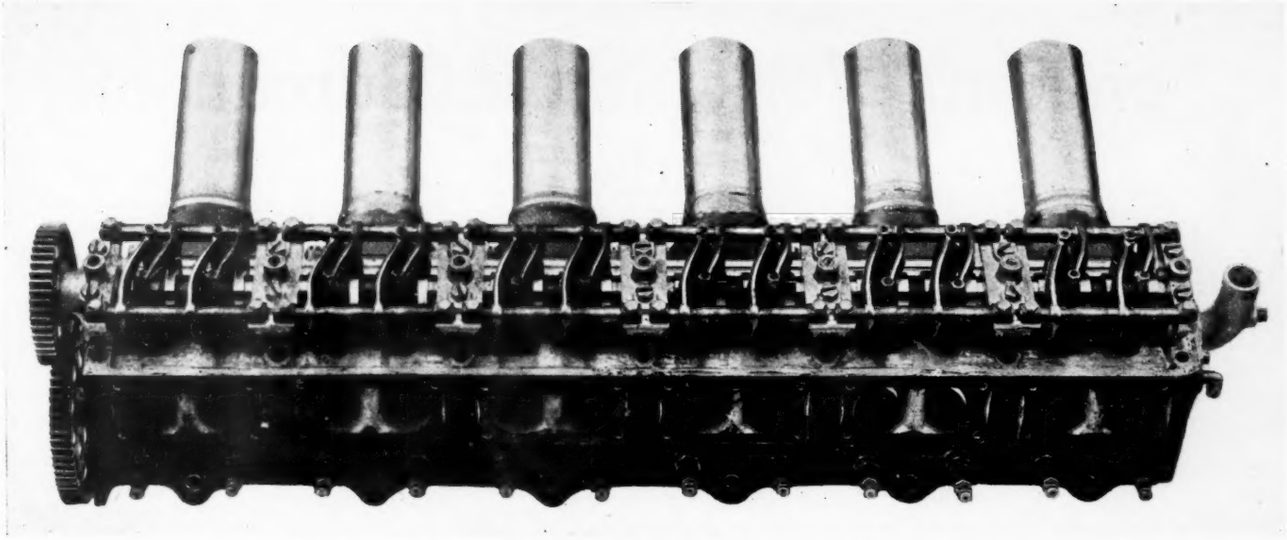


Fig. 8—Cylinder head assembly of Kessler super-charge engine for aviation purposes

unit of displacement. The curves given in Fig. 7 show three typical engines as compared with a Kessler engine, from a power output standpoint, according to claims made by the manufacturer. Curves A, B and C were made from test data of standard stock engines reduced to the basis of a 247 cu. in. piston displacement. Curve A was made by a 3⅛ by 5-in., six-cylinder engine; B was made by a 3⅞ by 4½-in. four; and C, a 3½ by 5¼-in. six. The curves all show marked drops at from 1600 r.p.m. up, the peak of the curve depending upon the valve timing.

The Kessler is a 3¾ by 3¾-in. six, with practically a straight line power curve between 800 and 2400 r.p.m. This curve is not a direct record of an actual engine run, but is based on test runs of similar engines, the data of which were compared and reduced to the displacement volume of a 3¾ by 3¾-in., six-cylinder engine with valve characteristics, etc., the same as in a sample Kessler engine just about to be constructed.

This curve indicates that by the use of a super charge the Kessler engine works in a much higher speed field than the ordinary types of engine and consequently would probably employ a much greater gear reduction than is utilized at the present time. As a matter of fact, the manufacturers believe that a ratio in the neighborhood of 5¾ to 1 or more would secure the greatest advantage from the engine. The claim of 100 hp. at 2900 r.p.m. from a 3¾ by 3¾-in. six appears radical at first sight, but the Kessler company states that in view of the results obtained in tests made on Government engines, this is considered a conservative estimate.

Engineers from motor car companies who have gone over the designs and have seen aviation engines built in accordance with this cycle have expressed their opinion that results of the kind denoted in the horsepower curve herewith are highly probable. One large concern has placed a provisional order for several thousand engines, provided certain output conditions less severe than this can be met by the engine.

From a design standpoint it is not necessary to depart very radically from ordinary practice in the construction of an engine. A very interesting piston has, however, been worked out by Kessler and is illustrated herewith. This piston is closed across the base, with a slot and webbed housing which encloses the top of the rod, thus giving a higher crankcase compression by eliminating the volume usually contained within the piston. The pistons are made either with a flat head or slightly domed. It has been found on aviation engines that were taken down and examined after long runs that this head is kept remarkably cool and free from carbon by the air blast from the super-charging air.

Furthermore, it is part of the theory of Kessler that the cushioning air lying on top of the piston also has the effect of preventing the extreme heat from reaching the head of the piston in the way that it does in the case of the ordinary type of engine at the point of maximum pressure, or at the peak of combustion.

As will be noted in the illustration herewith, Kessler

(*Continued on page* 1308)

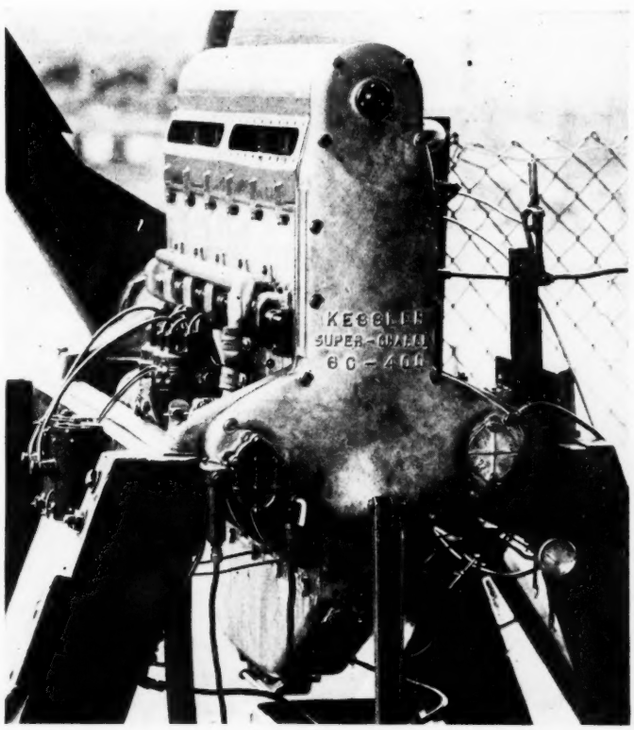


Fig. 9—Six valve per cylinder Kessler aviation engine on testing stand during experimental work. This is a six-cylinder 5½ x 6 in. engine (855 cu. in. displacement) weighing 578 lb.

Ignition Work at the Bureau of Standards*

Effects of Various Types of Spark on Engine Power—Spark Plug Faults and Their Remedies—Standard Tests, Methods and Specifications of Spark Plugs—Effects of the Auxiliary Gap

By Francis B. Silsbee

I—INTRODUCTION

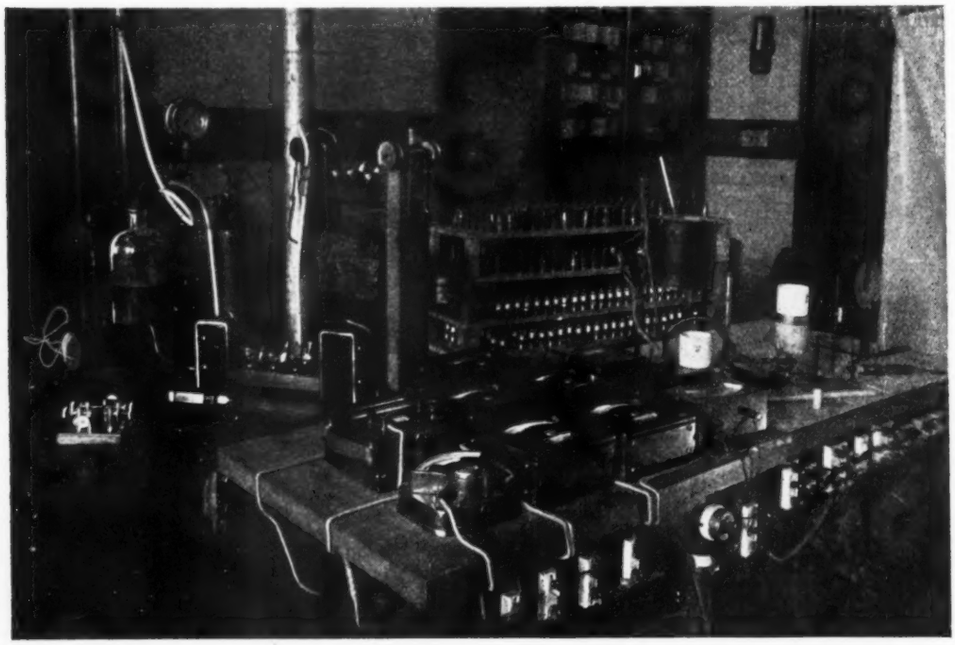
DURING the past two years the Bureau of Standards has been carrying on an extensive study of various problems connected with internal-combustion engines and their accessories. While the work was intended primarily to assist in the development of prime movers for aircraft, the results are, of course, almost equally applicable to gasoline engines used for any of the myriad other purposes—trucks, tractors, tanks, motor boats, etc.—to which they are applied.

The work was undertaken at the suggestion of the National Advisory Committee for Aeronautics, and has consisted in a large measure of specific tests of various devices submitted by the different military branches of the Government, together with a systematic investigation of the more fundamental problems. Active cooperation has been maintained with the Bureau of Aircraft Production and with the Navy Department on the one hand, and with the Society of Automotive Engineers and the various manufacturers interested, on the other.

The Bureau of Standards was thus enabled to act as a connecting link between the producers and the consumers, and, being unbiased by commercial relationships, it could give to both impartial testing and consulting service. The laboratory facilities permitted the carrying out of many delicate measurements not readily undertaken by industrial concerns, and much special apparatus was constructed for the purpose. On the other hand, the difficulties attendant upon factory production were fully recognized, and care was taken not to carry the development of details so far as to trespass upon the problems more properly handled by the manufacturer.

The experiments and methods of general interest have been described in detail in a series of Aeronautic Power Plant Reports issued by the Bureau, and will be printed in full in the Fourth Annual Report of the National Advisory Committee for Aeronautics. They will be referred to below by their numbers in both the A. P. P. series and the N. A. C. series.[1]

**During the war this work was carried on with various special military funds which are no longer available. It is to be hoped that the work already accomplished, and the problems which lie in the future, are of sufficient value to the progress of the automotive industries to justify the new Congress in supplying funds to continue the work during the reconstruction period.*—EDITOR.



Corner of spark plug laboratory. At the left are the pressure tank and the glass bell jar used in measuring gas leakage. At the right are the electric furnaces and in the center the instruments used in measuring the electrical resistance of the insulator. At the rear are sample plugs and porcelain cups

[1]A limited number of these reports is available for distribution by the Bureau of Standards and will be sent upon application to parties directly interested in the results. An additional supply of reprints of the N. A. C. A. Reports will be available later. The titles and numbers of these reports are as follows: [*See foot of next page.*]

The ignition work formed one branch of this general investigation, the other divisions being studies of carburetion, radiators, fuels, lubrication, and the effects of altitude upon engine performance. It is the purpose of this article to outline the various phases of the ignition work, to show their relations to each other and to the general question of engine performance, and to point out some of the outstanding problems which should be attacked in the immediate future.

The process of ignition in an internal combustion engine is essentially a trigger effect, i. e., a very small cause produces a very large effect which bears no direct relationship to the magnitude of the cause. Thus the energy delivered to the crankshaft of a Liberty engine by a single explosion is over 100,000 times the energy of the spark which initiated that explosion.

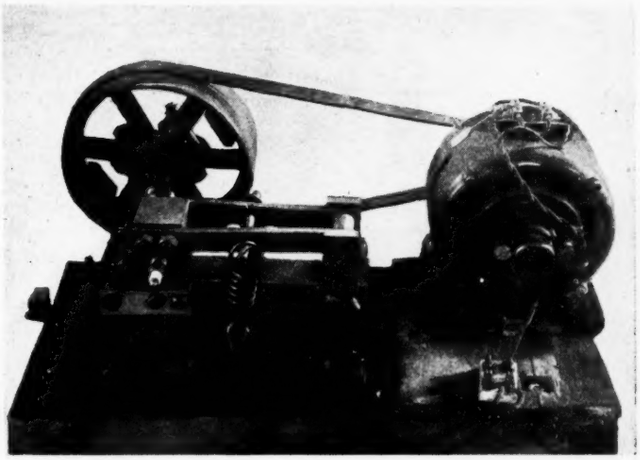
The problems met with in this work are therefore different from those usually occurring in engineering practice, and instead of studying the changes in one variable such an engine power which results from corresponding changes in another variable, such as mixture ratio or altitude, we are interested only in the effects of radical changes in the quality of the spark and particularly in the conditions which may determine the presence or absence of any spark at all.

The work therefore naturally divides itself into two parts, first, a study of the actual phenomena of the ignition of a combustible mixture by an electric spark, and, second, a study of the apparatus used to produce the spark and of the various troubles which are encountered in its operation.

II—IGNITION OF GASOLINE MIXTURES

Comparatively little work was done on the former of these problems, for two reasons. First, a complete study of the phenomena concerned would require a very long and elaborate research, and could not have been completed in time to yield results of any military value even if the war had lasted much longer than it did. Secondly, the bulk of the experimental evidence available, as well as preliminary experiments which were made at the Bureau, indicated that there was little likelihood of obtaining any marked increase in engine power by modifying the method of ignition.

A.P.P. No.	N.A.C.A. No.	Title
12	52	Temperature Measurements in Spark Plugs Having Brass and Steel Shells.
13	56-II	Measurement of Heat Energy per Spark of Various Ignition Systems.
14	54	Effect of Gas Pressure and Temperature on the Sparking Voltage of Spark Plugs.
15	56-I	A Method for Measuring the Heat Energy of Ignition Sparks.
16	58-II	A Method for Measuring Transformation Ratio and Coupling in High Tension Magnetos.
17	51-III	Methods for Tests of Spark Plugs.
18	53-I	Methods for Measuring Resistivity of Insulating Materials at High Temperatures.
19	53-II	Electrical Resistance of Various Insulating Materials at High Temperatures.
20	58-I	The Cycle of Operations of Jump-Spark Ignition Systems.
21	51-II	Gas Leakage and Its Relation to Design and Construction of Spark Plugs.
22	51-I	Causes of Failure of Spark Plugs.
23	53-III	The Production of Special Spark Plug Porcelains.
31	57	A Preliminary Report on the Use of Subsidiary Spark Gaps in Ignition Systems.
35	53-IV	Cements for Spark Plug Electrodes.
36		Causes of Cracking of Ignition Cable.



Machine for testing spark plugs for resistance to mechanical shock

The experiments performed along this line consisted in measuring the power of an engine ignited by sparks of different quality. These types of spark were: (a) the usual magneto spark which has an initial current of about 0.070 ampere and lasts 0.002 second; (b) the same system with an auxiliary spark gap in series with the plug (this has the effect of decreasing the duration and energy content of the spark to about half the former value); and (c) the same system with a condenser connected in parallel with the spark plug. This has the effect of greatly increasing the initial value of the current but produces a highly damped oscillatory discharge of very high frequency lasting only a few hundred-thousandths of a second.

Precisely the same power was obtained from the engine with each type of spark. This result, together with similar data obtained elsewhere, indicates quite strongly that the slogan "A spark's a spark" is a fairly safe guide in ignition work. While this is apparently contradictory to the widely held belief in the peculiar efficacy of "fat" or "hot" sparks, it is highly probable that all cases of trouble from so-called "weak" sparks are really caused by the entire absence or wrong timing of the spark.

The presence of a spark external to the cylinder or even at a series gap is no certain indication that a spark is produced within the cylinder if the plug is in poor condition. There are, however, many interesting questions to be settled along this line, as, for example: Is a spark of large heat content and long duration beneficial in cases where the carburetion is poor and the fuel is in the form of drops or spray? What effect do various types of spark have on the velocity of flame propagation in the cylinder? Is there an appreciable time elapsing between the passage of the spark and the beginning of the spread of the flame? A method for the measurement of the velocity of flame propagation has been developed at the Bureau and will permit a direct attack on these problems.

III—STUDY OF APPARATUS

The second class of investigations, namely, the study of various types of ignition apparatus to determine the relative merits of those then available and to indicate the possibilities for improvement, showed much more prospect of yielding results of immediate value, and the bulk of the work during the war was directly or indirectly of this nature. Since the results mentioned above indicated that the engine performance did

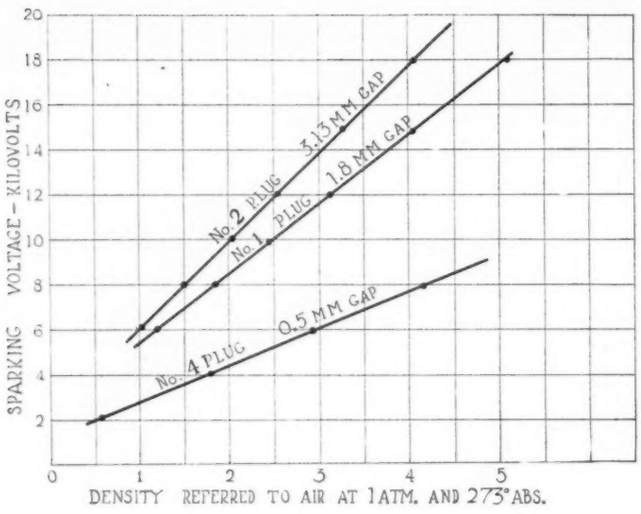

SPARKING VOLTAGE – KILOVOLTS
DENSITY REFERRED TO AIR AT 1ATM. AND 273°ABS.
No. 2 PLUG 3.13 MM GAP
No. 1 PLUG 1.8 MM GAP
No. 4 PLUG 0.5 MM GAP

Fig. 1—Variation of spark plug voltage with length of and pressure at gap

not depend to any considerable extent upon the quality of spark produced, an estimate of the relative merits of and improvements in ignition apparatus should apparently be based primarily upon the reliability of the apparatus under service conditions and the ability of the system to function even if the conditions under which it is required to operate become unduly severe.

"The proof of the pudding is in the eating," and it is obvious that the reliability of a given make of spark plug, for instance, can ultimately be determined only from the compilation of accurate statistical data on the life and final cause of failure of several thousand such plugs in a given type of engine. The securing of such statistical data is in no sense a laboratory job and can be carried out most easily by the maker, either of the accessory in question or of the completed engine.

Even when a large number of engines are in constant use, as at a flying-field, it is no easy matter to obtain accurate statistics, and the absence of satisfactory data of this nature has been felt throughout the work, even up to the present time, as the most serious single limitation upon the progress of developmental work.

Laboratory experiments can, however, show the details of certain specific types of failure, can determine the properties of the materials concerned, and can thus indicate the magnitude of the factors of safety and lead to improvement in materials and design.

IV—CONDITIONS OF OPERATION

It became evident early in the work that more definite knowledge was needed of the conditions under which the spark plugs and ignition system were required to operate. Preliminary experiments were therefore made to measure the temperature at various points in a spark plug while operating in an aviation engine, and of the voltage which was required to pass a spark through the compressed and heated charge in the cylinder at the end of the compression stroke. These experiments are described in detail in A. P. P. Reports Nos. 12 and 14 (N. A. C. Reports Nos. 52 and 54).

The burning gases in the combustion space probably reach a temperature of 2500 deg. C., but the duration of this high temperature is so short and the frequency of repetition of the engine cycle is so rapid that the spark plug maintains a much lower and a practically steady average temperature. In the experiments the tip of the electrode was found to reach an average temperature of about 900 deg. C., while the porcelain up in the body of the shell was heated to 250 deg. C., and the metal of the shell was about 100 deg. C.

There remains much work to be done on the effect on spark plug temperatures of variations in the speed and mean effective pressure of the engine and also of the temperature distribution in plugs of various types. The rate of heat transfer from the hot gases to the material of the plug is still unknown and the degree to which the plug temperatures can be reduced by increasing the thermal conductivity of the insulator is consequently undetermined.

A study of the conditions of temperature, mixture ratio, turbulence, etc., under which the deposition of carbon on the insulator will occur and of the effect of various shielding devices on the rate of deposition is also of very immediate practical value, but is as yet a virgin field.

The voltage required to produce a spark in air at various pressures and temperatures was found to depend upon only the density of the air and to be nearly proportional to the density as shown in Fig. 1. From this plot and the known compression ratio of any engine, it is possible to estimate the increase in sparking voltage resulting from the compression. Measurements with a special crest voltmeter of the voltage actually applied to the plugs in a Hall-Scott engine while running at full power indicated a value of 6000 volts, which is in good agreement with the above data.

V—OUTLINE OF OPERATION OF IGNITION SYSTEM

A second essential preliminary to an investigation of the performance of ignition systems is to have a clear and definite understanding of the theory of their operation. The high-tension magneto and the induction coil are exceedingly complex electrical systems, and while the general principles of their operation are well known, there exists among both manufacturers and users much confusion of thought as to the precise functions of the various parts.

This condition is due in part to the fact that the industry originated with the German Bosch Co. and has grown in considerable measure, though with notable exceptions, by imitating their designs. Moreover, with the exception of several very excellent articles which have been published recently by Biffi[1] in Italy, Armagnat[2] in France, and Young[3] in England, and the highly mathematical papers of Jones[4] and of Campbell[5] there is

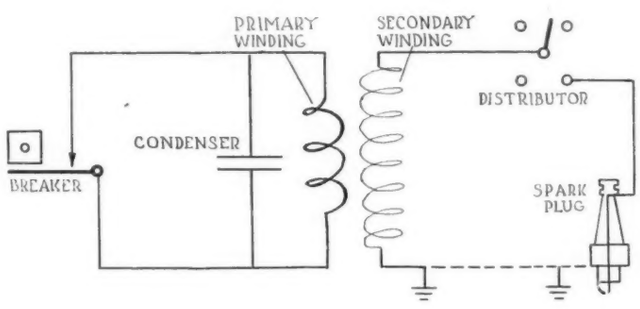


Fig. 2—Diagram of high tension ignition circuits

[1]Biffi, E. L'Elettrotecnica 5, pp. 302, 326, 386, 407, 1918.

[2]Armagnat, H. Rev. Electrique 23, pp. 321-333, 1915; Electrician 76, pp. 865-899.

[3]Young, A. P. Aeronautical Journal, pp. 142-252, 1817; Automobile Engineer, March, 1915.

[4]Jones, E. T. Phil. Mag., Vol. 36, p. 145, August, 1918.

[5]Campbell, N. Phil. Mag., Vol. 37, p. 284 and p. 372, March and April, 1919.

no published data dealing at all deeply with the subject. As an attempt to clarify the situation A. P. P. Report No. 20 (N. A. C. No. 58-I) was prepared which discusses in detail the cycle of operations of the jump-spark ignition system and gives data showing the order of magnitude of the various quantities involved.

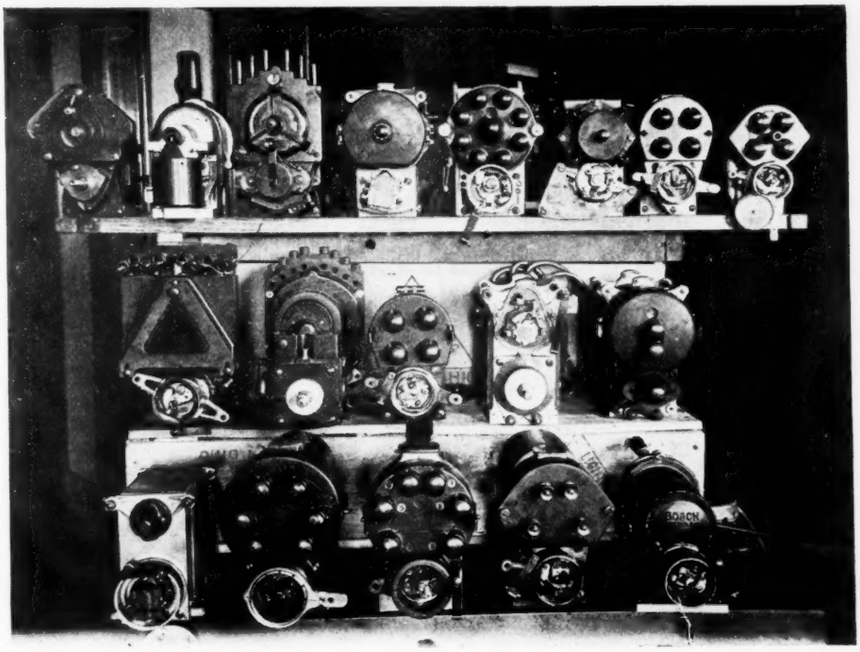
The usual type of ignition system as indicated in Fig. 2 consists essentially of an induction coil which comprises an iron core surrounded by a primary winding of a few turns (about 150) of coarse wire and a secondary winding of many turns (about 10,000) of fine wire. The secondary is connected through the distributor to the central electrode of the spark plug in the proper cylinder of the engine. The primary is supplied with a current (3 to 5 amperes) either from a storage battery or in the case of a magneto by induction from the relative motion of the core and a permanent magnet. When a spark is desired in the engine, the primary current is suddenly interrupted by the breaker and the resultant rapid decrease in the magnetic flux through the secondary winding generates in it a sufficient voltage to produce a spark at the terminals of the spark plug. There are two essential characteristics of any apparatus of this type which must be borne in mind in considering its behavior under adverse conditions:

First, with the secondary circuit open, and with no safety gap present, the voltage will build up to a certain maximum value (10,000 to 20,000 volts) which is determined principally by the inductance and capacity of the circuits, and no spark will be produced unless the breakdown voltage of the gap between the spark plug electrodes is less than this value. A safety gap may, of course, limit the voltage to some lower value.

Second, if the spark plug is shunted by a resistance, the maximum voltage obtained across its terminals is very considerably reduced, the reduction being greater the smaller the shunting resistance. With most of the ignition systems studied, the voltage reached was found to become less than 6000 volts required to produce a spark if the shunting resistance was much less than 100,000 ohms.

It may therefore be said that present practice divides the burden of supplying satisfactory ignition between the spark plugs on the one hand and the magneto or coil on the other at the limits just mentioned. The spark plug is thus called upon to perform three functions: First, to maintain a gap between its electrodes which shall have a breakdown voltage of approximately 6000 volts; second, to maintain an insulation resistance between its terminals of not less than 100,000 ohms; and, third, to be substantially gas-tight in order that the leakage of heated gas through the plug may not raise it to such a high temperature as to cause pre-ignition of the engine and destruction of the plug. Conversely, the magneto is required to deliver at the plug terminals at least 6000 volts, at the proper time in the cycle, even if the plug resistance is as low as 100,000 ohms.

In case of trouble with the plug, the magneto or coil is required to supply either a very high voltage in cases when the spark plug gap has become fouled with oil and consequently has a high breakdown strength, or else to supply an unusually large current in cases where the plug is fouled with carbon. In this latter case, the magneto must send such a current through the carbon deposit that the product of this current multiplied by the electrical resistance of the deposit is at least equal to the sparking voltage of the gap.



Group of magnetos submitted for test

VI—EXPERIMENTAL WORK ON SPARK PLUGS

The possible ways in which a spark plug may fail to fulfill its requirements may be enumerated as follows:

1. Fouling with carbon deposit causing short circuit.
2. Fouling with oil causing open circuit.
3. Cracking or breaking of the insulator.
4. Pre-ignition.
5. Conduction through the insulator.
6. Electrical puncture of the insulator.
7. Minor troubles, such as warping and corrosion of electrodes, etc.

The relative importance of these troubles depends upon the type of engine, and the statistical data available is too meagre to admit of a very definite conclusion on this point. The experience in the engine testing work at the Bureau and performance data obtained from France indicate that the order in which they are listed above is approximately that of decreasing importance.

A general discussion of these various types of failure will be found in A. P. P. Report No. 22 (N. A. C. No. 51-I) in which the origin and identification of each type of failure is described and possible remedies for some of them are suggested.

It appeared early in the work that there were no generally recognized standard tests to determine the ability of a spark plug to resist these various types of failure, and the first work undertaken was the devising of such tests and the embodying of them in specifications for the use of the Bureau of Aircraft Production.

A large number of plugs of different types were tested in various ways and the results of the laboratory tests were correlated as well as possible with their service performance in aviation engines at the Bureau and elsewhere. The results are incorporated in specifications

Nos. 28004 and 28017 of the Air Service and the methods finally adopted are described in detail in A. P. P. Report No. 17 (N. A. C. No. 51-III).

The tests cover the electrical resistance of the insulating material while hot, its resistance to cracking from sudden temperature changes, its resistance to breaking from mechanical shock, and its dielectric strength while cold, and also the gas tightness of the assembled plug.

More detailed studies have been made of several of the specific types of failure listed above, which were particularly susceptible to laboratory investigation. The first of these was the conduction of electricity through the material of the insulator.

It had long been known that ceramic materials when heated lost their insulating properties and became to a certain extent conducting. In 1916 reports came to the attention of the Bureau that spark plug failures were setting a serious limit to the design of aircraft engines abroad, and that the trouble seemed to be due to the conducting properties of the insulators at the high temperatures encountered in the most modern engines. This trouble is frequently spoken of as "cutout."

Measurements were made of the electrical conductivity over a wide range of temperature of over 100 materials from different sources. This included spark plug insulators of porcelain, mica, glass, quartz, etc., as well as a number of porcelains prepared by the Ceramic Laboratory of the Bureau.

The method used in this work is described in A. P. P. Report No. 18 (N. A. C. No. 53-I), and the results in A. P. P. Report No. 19 (N. A. C. No. 53-II). By combining the data thus obtained with the measurements mentioned above of the temperatures in spark plugs while operating in an engine, one can estimate the resistance which a plug made of any of these materials would have in operation On making this comparison it appears that except for the poorest materials tested the resistance of the plug would be well on the safe side of the limiting value of 100,000 ohms.

Consequently this trouble can occur only with very poor materials, with very weak ignition systems, or with engines which are very much hotter than those experimented with at the Bureau. Later reports from abroad make no mention of this trouble, and its importance was apparently much exaggerated.

The testing of sample plugs submitted by the Bureau of Aircraft Production enabled the laboratory to accumulate data on the gas tightness of plugs of a variety of designs. This data has been analyzed and tabulated in A. P. P. Report No. 21 (N. A. C. No. 51-II).

It appears from this work that except in plugs where the insulator is moulded between the metal parts there is little connection between the design of the plug and its gas tightness, the latter depending much more on workmanship than on design. Observations at different pressures and temperatures show that the apertures through which the leakage occurs are in general opened up by high pressure and by heating. For this reason the routine tests are made while the plug is heated to 150 deg. C.

Two specific cases of electrode troubles were also investigated by the Bureau. In the first of these the electrodes in service broke off flush with the tip of the insulator. It was found that the cementing material became chemically active at the temperature of operation and attacked the metal electrode, rapidly eating it away. This trouble was remedied by substituting a different and inert filling material in the cement.

The second investigation was on the breaking of the side electrode in plugs where it was fastened at both ends. Microphotographs showed that prolonged heating of the nickel wire caused the formation of films of oxide in the cracks between the crystal grains of the metal. If the wire is subject to even a very slight tension, the cracks sink in deeply and the wire breaks in a short time.

If the tension is absent the cracks extend less rapidly and the life of the electrode is prolonged. It is probable that the well known slow corrosion of the electrodes by the spark is due to this effect, which causes the individual crystals to drop out of the wire as each becomes completely surrounded by its oxide film. These investigations are treated more fully in A. P. P. Reports No. 35 and No. 54 (N. A. C. No. 53-IV) respectively.

The most important part of the spark plug work was the development by the Ceramic Laboratory of the Bureau of a new porcelain body for use as a spark plug insulator. This work, which is described in A. P. P. Report No. 23 (N. A. C. No. 53-III), was begun while "cutout" was believed to be an important factor and the composition of the porcelain was chosen so as to give a high insulation resistance even at high temperatures. The various experimental porcelains mentioned above were made up with a view to determining the effect of various constituents upon the conductivity.

Measurements were also made of the thermal expansion over a wide range of temperature, and of resistance to sudden temperature changes, in the case of many of the bodies. By a careful balancing of the various components and the substitution of stable compounds like sillimanite ($Al_2O_3SiO_2$) in place of the free quartz, which tends to change its crystal form and dimensions at high temperatures, a porcelain-like body was finally obtained which could be prepared commercially and which was very definitely superior mechanically, thermally and electrically to any of the materials previously on the market. This composition has been made available to the public and is now being produced, with certain slight modifications, on a large scale by one of the largest spark plug manufacturers in the country.

VII—MAGNETO INVESTIGATIONS

The work on magnetos and induction coils has been much less complete than that on spark plugs, because of the much greater complexity of the subject and the less acute need for results. One of the early tests requested by the Signal Corps was the measurement of the energy output of a number of magnetos of different types.

The measurement of power electrically at the high voltages occurring in ignition systems is a rather difficult and delicate operation, but it is fortunately very simple to measure the same energy in the form of heat after it has been dissipated in the spark. Accordingly, as a preliminary to a more complete study of the subject a number of calorimetric measurements were made of the heat energy of the spark delivered at various speeds by the ignition system submitted.

The method used in this work is described in A. P. P. Report No. 15 (N. A. C. No. 56-I), and the results obtained are given in A. P. P. Report No. 13 (N. A. C. No. 56-II). The apparatus consists essentially of a hollow block of copper containing the spark gap. The rise of temperature of the copper which results from the passage of a known number of sparks is noted and compared with the rise produced by dissipating a known amount of energy in a heating coil, which is also enclosed in the block.

From this comparison the actual heat per spark can be computed in absolute measure. In considering these results it must be carefully borne in mind that the heat content of a spark is by no means a direct measure

of its igniting power and that it is only one of many items to be considered in judging the relative merits of different ignition systems.

Extensive oscillographic tests have been made on a number of magnetos to determine the instantaneous values of current, voltage, etc. during the operation of the machine. The wave forms obtained include the primary current on short circuit and the voltage on open circuit, together with the instants of opening and closing of the breaker. Also the primary and secondary currents and the primary voltage while operating normally have been recorded.

The oscillograph vibrator is not quick enough to indicate accurately the exceedingly rapid building up of voltage just after the primary "break," but the other features of the operation are brought out very clearly in the photographs.

Owing to the expense of reproducing the photographic records, copies of these oscillograms, which constitute A. P. P. Report No. 28, are being sent only to the manufacturers of the particular machines tested and to a few officials of the War Department. The results of measurements of the films are, however, being incorporated in other reports such as A. P. P. Report No. 20 (N. A. C. No. 58-I) dealing with various phases of the subject.

In interpreting the oscillograms, it was found desirable to know the ratio of secondary to primary turns in the particular coils tested and the combination of circuits described in A. P. P. Report No. 16 (N. A. C. No. 58-II) was devised to measure this ratio.

A considerable amount of work has also been done to develop methods for measuring the intrinsic constants of ignition apparatus, such as the electrostatic capacity of the secondary winding and the eddy currents in the core. It is hoped that the combination of quantitative data on these effects with a fairly simple mathematical theory of the electrical oscillations involved will enable the design of ignition apparatus to be put on a more scientific basis.

A comparison of the present empirical practice in this industry with the high degree of refinement attained in other branches of electrical engineering, as for example the design of power transformers in which the performance can be determined to a fraction of 1 per cent, indicates a wide field for advancement.

The various phases of this subject are so closely interlocked that the entire field must be worked out as a unit and consequently no partial reports have as yet been issued covering this part of the work.

The insulated cables used to connect the spark plugs with the distributor occasionally give trouble after considerable service by cracking of the insulation. This trouble usually occurs where the cable has been bent at a sharp angle.

At the request of the Bureau of Aircraft Production, this effect was investigated and the results were reported in A. P. P. Report No. 36. It was found to be due to a chemical attack on the rubber by ozone, which is in turn produced by the silent electrical discharge which occurs at the surface of the cable.

This chemical action is normally uniformly distributed and very slow, but, if the rubber is under tension as at the outside of a bend, the layer of oxide is pulled apart, continually exposing a fresh surface. This causes the cracks to sink rapidly into the material, until the insulating wall becomes so thin that it is punctured by the igniting voltage. The remedies for this trouble are the use of rubber compounds which are least susceptible to oxidation, the use of an impregnated air-tight braid and the avoidance of sharp bends in the wiring.

The problem of satisfying the requirements of ignition systems may be attacked, not only by the direct method of using an efficient and powerful source of energy, but also by the use of certain auxiliary devices which tend to produce the desired qualities of high voltage or large current.

The simplest of these for firing short circuited plugs is an auxiliary spark gap connected in series with the spark plug but external to the cylinder so that it will maintain a perfect insulation and definite breakdown voltage. Such a gap prevents the leakage of current across a fouled spark plug and permits the secondary voltage of the coil to build up in a normal manner. When this voltage becomes equal to the sparking voltage of the auxiliary gap, the gap breaks down and this full voltage is suddenly impressed on the spark plug, producing a spark at its gap also.

It has been found possible with this device to produce regular firing in an engine with a plug shunted by a resistance as low as 5,000 ohms, which is a very material reduction of the limit of 100,000 ohms specified above. Unfortunately, manufacturers of this type of device have brought it into unmerited disfavor by making impossibly extravagant claims for it in their advertising. A. P. P. Report No. 31 (N. A. C. No. 57) contains a discussion of the theory of this type of circuit and the results of trials of it in the laboratory and on engines.

The Lodge high frequency system is closely analogous to this series gap circuit, although the auxiliary gap is in parallel with the coil rather than in series, but is equally effective in firing a heavily shunted plug. The Dean high frequency system on the other hand is intended to supply a high voltage to overcome trouble from coating of the plug terminals with oil. The use of high frequencies permits the generation of very high voltages with a moderate number of turns, and it seems probable that further developments in ignition apparatus may be expected along this line.

VIII—SUMMARY

The foregoing outline of the ignition work at the Bureau of Standards has indicated the scope and purpose of the work. It has included a brief study of the effects of various types of spark discharge upon the power developed by a gasoline engine, and has indicated the conditions of temperature and voltage at which a spark plug is required to operate.

The cycle of operations of the jump spark ignition system has been discussed in some detail, and typical values of the various quantities of importance are stated. Standard methods of tests and specifications have been developed for spark plugs and a new porcelain body has been developed which is superior to those previously available for use in spark plug insulators.

Certain specific troubles, such as cracking and corrosion of electrodes, have been studied. Calorimetric measurements have been made of the power delivered by various typs of magnetos and extensive oscillographic tests have shown in detail various phases of operation.

A peculiar type of failure of the insulated cables connecting the spark plugs to the distributors has been studied, and tests have been made of the feasibility of the use of series spark gaps in firing fouled plugs.

It appears that from the above discussion the usefulness of the laboratory lies principally in studying specific difficulties, which experience has shown to be serious, in testing the properties of materials, in developing satisfactory standard methods of measurement, and in advancing the more theoretical side of the subject by fundamental research.

Specifications of Stock Engines for Pa

IN the following table are given the specifications of 96 models of automobile, truck and tractor engines now on the American market, the product of 34 different makers. The piston displacement ranges from 86.6 cu. in., which is only little beyond the motorcycle size, to 1344 cu. in., which is about the limit of size used for heavy tractors. This table should prove handy to manufacturers and engineers in search of an engine of a given output and certain characteristics.

The table also is instructive as regards trends in design. In view of the fact that some people have been inclined to regard the 4-cylinder engine as obsolete, on account of its limited use in passenger car models, the very strong representation of the four-cylinder type in the table is certainly interesting. Of the 96 engines listed 77 are of the four-cylinder type, while the remaining 19 are divided between 2, 6, 8 and 12-cylinder types.

It will be noticed that block casting of cylinders is becoming a very common practice, except for the largest bores. Although the practice of making cylinder heads detachable is rapidly gaining ground, there is still a goodly number of engines with integral heads. Some of the engines listed have been on the market for a number of years, and a change from integral to detachable head not only involves a complete redesign of the cylinder block but the making of complete new patterns and core boxes and extensive changes in manufacturing equipment.

The L-head type of cylinder predominates, but the valve-in-head construction is well represented and is preferred by many designers of kerosene-burning tractor engines. Mushroom cam followers are much more numerous than roller type cam followers, the two types being represented in about the proportion of 2:1.

The table shows that although there are more engines in which the cylinder axis intersects the crankshaft axis, the practice of offsetting the cylinders is pretty well established. In this connection it must be remembered that off-setting is of greatest advantage in a low-speed engine and a rather large proportion of the engines covered by the table is of this type.

As regards intake manifolds, the majority of them are separate from the cylinder block and head casting, but the integral manifold is not greatly in the minority.

Most engines are designed for pump circulation of the cooling water and a centrifugal pump for the purpose comes with the engine.

MAKE AND MODEL OF ENGINE	Designed for: (Cars, Trucks, Tractors)	Number of Cylinders	Bore and Stroke	Piston Displacement (Cu. In.)	Cylinders Cast	Is Cylinder Head Detachable?	Valves Placed	Valve Port Diameter (In.)	Valve Lift, In.	Type of Cam Follower	Volume of Compression Space, Cubic Inches	Piston Length, In	Number of Piston Rings	Is Scraper Ring Used?	Weight of Piston with Wrist Pin and Rings (Lb.)	Weight of Connecting Rod (Lb.)	Length of Connecting Rod (C. to C.)	Width of Wrist Pin Bearing (In.)	Diameter of Wrist Pin Bearing (In.)	Width of Connecting Rod Lower End Bearing (In.)	Diameter of Connecting Rod Lower End Bearing (In.)	Diameter of Crankshaft	Number of Crankshaft Bearings	LENGTH OF CRANKSHAFT BEARINGS			Is Cylinder Offset?	If Offset—How Much?
																								Front	1st Int.	Rear		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Beaver	JA	T.. Tr.	4	4 1/2 x6	381.7	B.	Yes	I	2	3/8	R.			4	Yes.													
Beaver	JA	T. Tr.	4	4 3/4 x6	425.2	B.	Yes	I	2	3/8	R.			4	Yes													
Bradley	A1	C.	4	4 1/8 x5 1/2	294.6	B.	No.	t.R.	2x1 3/4			19.2	5 1/2	3	No.	4.38	6.20	12	2	1 1/16	2 1/4	1 3/4	2	3	2 3/4	2 3/4	4	Yes.	3/8
Buda	RU	T.	4	3 1/2 x5 1/2	197.3	B.	No.	R.	1 1/2	3/8	M	15.1	5	3	No.	2.80	4.06	11 1/4	1 7/8	1 1/16	2	1 7/8	*	3	2 5/8	2 1/4	3 1/4	No..	
Buda	WU	T.. Tr.	4	3 3/4 5	225.4	B.	No.	R.	1 1/2	3/8	M	17.4	5	3	No.	3.22	4.06	11 1/4	1 7/8	1 1/16	2	1 7/8	*	3	2 5/8	2 1/4	3 1/4	No..	
Buda	IU	T.. Tr.	4	4 x5 1/2	276.5	B.	No.	R.	1 7/8	I. 5/16, E. 3/8	M	23.0	5 3/8	3	No.	4.05	6.25	12 1/4	2 1/8	1 1/8	2 1/2	2 1/8	*	3	3 1/4	2 3/4	4	No..	
Buda	HU	T.. Tr.	4	4 1/2 x5 1/2	312.0	B.	No.	R.	1 7/8	I. 3/16, E. 3/8	M	26.0	5 3/8	3	No.	4.62	6.25	12 1/2	2 1/8	1 1/8	2 1/2	2 1/8	*	3	3 1/4	2 3/4	4	No..	
Buda	OU	T.. Tr.	4	4 3/4 x5 1/2	242.9	B.	No..	R.	1 7/8	I. 5/16, E. 3/8	M	26.0	5	3	No.	3.48	5.96	11 7/8	2	1 1/16	2 3/8	1 7/8	*	3	3 1/4	2 1/4	4	Yes.	3/16
Buda	OU	T. Tr.	4	4 1/2 x5 1/2	294.6	B.	No.	R.	1 7/8	I. 5/16, E. 3/8	M	20.2	5 3/8	3	No.	4.88	6.14	11 7/8	2 1/8	1 1/16	2 3/8	1 7/8	*	3	3 1/4	2 1/4	4	Yes.	3/16
Buda	TU	T.. Tr.	4	4 1/4 x5 1/2	312.0	B.	No.	R.	1 7/8	I. 5/16, E. 3/8	M	24.7	5 3/8	3	No.	5.16	6.14	11 7/8	2 1/8	1 1/16	2 3/8	1 7/8	*	3	3 1/4	2 1/4	4	Yes.	3/16
Buda	YTU	T.. Tr	4	4 1/2 x6	381.7	B.	Yes	R.	2 1/8	I. 5/16, E. 3/8	M	25.9	6 1/4	3	No.	5.16	7.13	13 1/4	2 1/4	1 1/4	3	2 1/4	*	3	3 1/2	3 1/4	4 1/2	No..	
Buda	ATU	T.. Tr.	4	4 3/4 x5 1/2	389.9	B.	Yes	R.	2 1/4	I. 5/16, E. 3/8	M	20.7	6 3/4	3	No.			14 3/8	2 3/8	1 3/8	3 1/8	2 1/2	*	3	4 1/8	3 7/8	4 3/4	No..	
Buda	BTU	T.. Tr..	4	5 x6 1/2	471.2	B.	Yes	R.	2 1/4	I. 5/16, E. 3/8	M	29.4	6 3/4	3	No.			14 3/8	2 3/4	1 3/8	3 1/8	2 1/2	*	3	4 1/8	3 7/8	4 3/4	No..	
Chief	F	Tr	4	4 1/2 x6	381.7	B.	Yes	I	2 1/8	3/8	R.	28.7	5 5/8	3	No.	5.50	5.12	12 1/16	2 1/4	1 1/2	2 3/4	2 1/2	2 1/2	3	3 7/16	3 1/8	4 1/16	No..	
Chief	F	Tr	4	4 3/4 x6	425.2	B.	Yes	I	2 1/8	3/8	R.	31.8	5 1/2	3	No.	5.62	5.12	12 1/16	2 1/4	1 1/2	2 3/4	2 1/2	2 1/2	3	3 7/16	3 1/8	4 1/16	No..	
Climax	K	Tr..	4	5 x6 1/2	510.5	P.	Yes	R.	2 1/4	5/16	M	55.3	5 3/8	3	No.	7.13	8.50	13	2 7/16	1 13/16	3	2 1/4	2 1/4	3	3 3/4	3 1/2	4 3/8	No..	
Climax	KU	Tr	4	5 x6 1/2	510.5	P.	Yes	R.	2 1/4	5/16	M	55.3	5 3/8	3	No.	7.13	8.50	13	2 7/16	1 13/16	3	2 1/4	2 1/4	3	3 3/4	3 1/2	4 3/8	No..	
Continental	N	C.. T	4	3 1/2 x5	192.4	B.	No.	R.	1 5/16	I. 3/32, E. 11/32	M	14.1	3 3/4	3	No..	2.84	3.75	10 1/2	1 1/2	1 3/32	2 3/16	1 7/8	2 1/8	3	3 1/8	2 1/2	3 3/4	No..	
Continental	N	C.. T	4	3 3/4 x5	220.9	B.	No.	R.	1 5/16	I. 3/32, E. 11/32	M	16.7	3 3/4	3	No..	2.98	4.00	10 1/4	1 1/2	1 3/32	2 3/16	1 7/8	2 1/8	3	3 1/8	2 1/2	3 3/4	No..	
Continental	C	T.	4	4 1/4 x5 1/2	280.6	B.	No.	R.	1 13/16	3/8	M	22.0	5 1/2	3	No..	3.98	4.90	11	1 3/4	1 3/32	2 1/4	2	2 1/8	3	2 3/16	2 7/16	2 1/4	No..	
Continental	C	T.	4	4 1/4 x5 1/2	280.6	B.	No.	L	1 13/16	3/8	M	22.0	5 1/2	3	No..	2.85	4.90	10 1/2	1 3/4	1 3/32	2 1/2	2 1/4	2 3/8	3	2 3/16	3	4 7/8	No..	
Continental	E	T.	4	4 1/2 x5 1/2	349.9	P.	No.	L	2 1/4	I. 5/16, E. 11/32	M	27.6	5 5/8	3	No..	5.34	6.50	11	2 1/4	1 7/16	3	2 1/4	2 1/4	3	3 3/4	3 3/4	4 1/2	No..	
Continental	E7	T.	4	4 1/4 x5 1/2	349.9	P.	No.	L	2 1/4	I. 5/16, E. 11/32	M	27.6	5 5/8	3	No..	5.34	6.50	11	2 1/4	1 7/16	3	2 1/4	2 1/4	3	3	3 3/4	4 1/8	No..	
Continental	B7	T.. Tr.	4	4 3/4 x6	425.3	P.	Yes	R.	2 1/8	11/32	R..	35.9	6 1/8	3	No.	7.32	8.50	13 1/4	2 1/8	1 7/8	3	2 3/4	2 1/2	3	3	4	4	No..	
Continental	7W	C.	6	3 1/2 x4 1/2	221.0	B.	Yes	R.	1 13/32	3/8	M	10.8	3 1/2	3	No..	2.00	2.44	8 1/2	1 1/8	7/8	2	1 1/32	2 1/8	3	2 5/16	3	3 1/2	No..	
Continental	9N	C.	6	3 1/2 x5 1/2	303.1	B.	No.	R.	1 1/32	I. 5/32, E. 11/32	M	15.7	4 1/2	3	No..	3.10	3.44	10 1/4	1 1/2	1 1/16	1 1/16	2 3/8	2 3/8	3	2 3/4	2 1/4	3 1/2	No..	
Doman		T.. Tr.	4	4 3/4 x6	425.3	P.	Yes	Opt..	2 3/8	3/8	M		6 5/8	3	No..	7.50	6.50	12 1/2	2 7/8	2 1/4	2 1/4	2 1/4	2 1/4	3	3 7/8	3 7/8	4 1/2	No..	
Doman		Tr	4	5 x7	791.6	S.	Yes	Opt.	2 3/4	7/16	M		7 1/4	3	No..	12.25	11 25	14	4	1 1/2	3 1/8	2 3/4	2 3/4	5	5	*12 1/2	6		
Elbridge		C.. T.. Tr	4	3 3/4 x4	176.7	B.	Yes	T-H					3 3/4	3	No.				1 1/8	1 1/16	1 1/2	1 1/2	1 1/2	3	1 1/2	2 1/8	3 1/2	No..	
Erd	T-TU	Tr	4	4 x6	301.7	B.	Yes	I	1 3/4	5/16	M	25.0	4 1/2	3	No..	3.88	5.62	11 1/2	2 1/8	1 7/32	2 3/8	2	2	3	2 9/32	2 3/8	4	No..	
Erd	CA	Tr.	4	4 1/2 x6	381.7	B.	Yes	I	2 1/8	3/8	M	30.5	6	3	No.	6.00	10.00	12 1/2	2 1/8	1 1/2	3 1/4	2 3/8	2 1/2	3	3 1/2	3 1/2	4 1/2	No..	
Erd	CA	Tr.	4	4 3/4 x6	425.2	B.	Yes	I	2 1/8	3/8	M.	34.0	6	3	No..	6.00	10.00	12 1/2	2 1/8	1 1/2	3 1/4	2 3/8	2 1/2	3	3 1/2	3 1/2	4 1/2	No..	
Falls	N	C.	6	3 x4 1/2	180.2	B.	Yes	H	1 1/4	9/32		7.9	3 1/2	3	No..	1.94	1.75	8 1/8	3/4	3/4	1 5/8	1 7/8	1 7/8	3	2 1/8	2	3	No..	
Falls	R	C.	6	3 1/8 x4 1/2	195.6	B.	Yes	H	1 1/4	9/32		8.6	3 1/2	3	No.	1.94	1.75	8 1/8	3/4	3/4	1 5/8	1 7/8	1 7/8	3	2 1/16	2	3	No..	
Falls	R1	C.	6	3 1/8 x4 1/2	195.6	B.	Yes	H	1 1/4	9/32		8.6	3 1/2	3	No.	1.94	1.75	8 1/8	3/4	3/4	1 5/8	1 7/8	1 7/8	3	2 1/16	2	3	No..	

Explanation of abbreviations: Numbers in brackets indicate the column to which reference is made.

(1) **C** = Car; **T** = Truck; **Tr** = Tractor.
(5) **B** = Block; **P** = Pairs; **S** = Singly.
(7) **H** = Head; **R** = Right; **L** = Left; **Op** = Opposite; **Sl** = Sleeve.
(10) **R** = Roller; **M** = Mushroom.
(29) **I** = Integral; **S** = Separate.
(30) **C-P** = Centrifugal Pump; **Th** = Thermo-Syphon; **G-P** = Gear Pump; **Opt** = Optional. **N-C** = Non-Circulating Splash.
(31) **S-P** = Splash-Pressure; **C-S** = Circulating-Splash; **Pr** = Pressure.
(32-35) **A** = Aluminum; **I** = Iron; **S-S** = Semi-Steel; **P-S** = Pressed Steel.

Passenger Cars, Trucks and Tractors

Pressure lubrication has greatly increased in popularity of late years, mainly in connection with the use of engines for tractor work and similar heavy duty. Non-circulating systems, which some people consider essential with kerosene-burning tractor engines, are still very rarely found on engines of this type.

A certain number of engine cylinders are cast of semi-steel, which, as is generally known, consists of gray iron to which a certain amount of steel scrap has been added. This addition of steel no doubt will change the physical properties of the metal in certain ways, notably by rendering it tougher, but it is a question in the mind of many engineers whether it will increase the resistance of the metal to abrasion; in other words, whether it will increase the life of a cylinder used as cylinders are used in tractor service.

It is noteworthy that no aluminum pistons are used in stock engines. Wherever the material of the cylinders is semi-steel, that of the pistons is the same.

Governors are fitted to practically all engines used in tractor work, but some manufacturers of these engines leave it optional with the purchaser what type of governor he should use.

More than half of all the engines are adapted for 3-point support, and the great majority are of the unit powerplant type.

With very few exceptions, the manufacturers of engines were quite frank about the weights of their machines, and this tabulation for the first time affords the opportunity of deriving the average weight of engine per N. A. C. C. horsepower, or per cubic inch piston displacement. There would be absolutely no use in taking averages for all of the engines, as the relative weights of passenger-car and tractor engines are quite different.

Chain drives for the camshaft and accessories drive shaft are not numerous. Their advantage being greater silence, and this having to be purchased at the price of greater manufacturing cost, one would expect to see the chain only on engines designed for passenger-car use. As regards designs of bell housing, it is interesting to note that while the S. A. E. standard housings are not universal, they are the next thing to it.

It will be noticed that the term "optional" occurs rather frequently in the table. This shows that the engine builders are willing to meet the desires of assemblers where this can be done without too much trouble.

Rear	Is Cylinder Offset?	If Offset—How Much?	Intake Manifold (Separate or Integral)	Water Circulated by	Lubrication System	Material of Crankcase	Material of Lower Half of Crankcase	Material of Cylinders	Material of Pistons	R.P.M. at which Maximum H.P. is Developed	R.P.M. at which Maximum Torque is Developed	Is Governor Fitted?	If so, what Type?	Governed Speed	Maximum Brake H.P. of Average Product	Weight of Engine Without Ignition or Carbureter (Lb.)	Overall Width of Engine (In.)	Overall Height of Engine (In.)	Overall Length of Engine (In.)	Type of Front End Drive	If Chain, what Type?	Adjustable or Non-adjustable	Points of Engine Support	Adapted for Heavy Fuel	Is Bell Housing Provided?	If so, what No. or Type?	MAKE AND MODEL OF ENGINE
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
1½	Yes.	½	I	C-P.	S-P.	S-S.	I	S-S.	S-S.	1200	800	Yes.	Own.		35	1000	20–17¾	38 1/16	36 1/16	G.			3-4	Yes.	Yes.	2, S.A.E.	Beaver JA
1½	Yes.	½	I	C-P.	S-P.	S-S.	I	S-S.	S-S.	1200	800	Yes.	Own.		40½	1000	20–17¾	38 1/16	36 1/16	G.			3-4	Yes.	Yes.	2, S.A.E.	Beaver JA
4	Yes.	3/8	S.	C-P.	C-S.	A.	A.	I	I	1400	900	No.			30	580	25	36	38	C.	S.		4	No.	No.		Bradley A1
3¼	No.		I	Th.	C-S.	I	I	I	I			Opt.				640	26	31 3/16	32 1/16	G.			3	No.	Yes.	3, S.A.E.	Buda RU
3½	No.		I	Th.	C-S.	I	I	I	I			Opt.		Opt.		640	26	31 3/16	32 1/16	G.			3	No.	Yes.	3, S.A.E.	Buda WU
4	No.		I	C-P.	Pr.	I	I	I	I			Opt.		Opt.		725	25 3/4	33 1/16	38 7/16	G.			3	No.	Yes.	3, S.A.E.	Buda IU
4	No.		I	C-P.	Pr.	I	I	I	I			Opt.		Opt.		725	25 3/4	33 1/16	38 7/16	G.			3	No.	Yes.	3, S.A.E.	Buda HU
4	Yes.	3/16	S.	C-P.	C-S.	I	I	S-S.	I			Opt.		Opt.		745	26	34 1/4	38 7/16	G.			3	No.	Yes.	3, S.A.E.	Buda QU
4	Yes.	3/16	S.	C-P.	C-S.	I	I	S-S.	I			Opt.		Opt.		730	26	34 1/4	38 7/16	G.			3	No.	Yes.	3, S.A.E.	Buda OU
4	Yes.	3/16	S.	C-P.	C-S.	I	I	S-S.	I			Opt.		Opt.		715	26	34 1/4	38 7/16	G.			3	No.	Yes.	3, S.A.E.	Buda TU
4¼	No.		S.	C-P.	Pr.	I	I	I	I			Opt.		Opt.			25 3/4	36 7/16	55 1/8	G.			3		Yes.	3, S.A.E.	Buda YTU
4¼	No.		S.	C-P.	Pr.	I	I	I	I			Opt.		Opt.			28 3/4	40 1/2	62 1/4	G.			3		Yes.	1, S.A.E.	Buda ATU
4¾	No.		S.	C-P.	Pr.	I	I	I	I			Opt.		Opt.			28 3/4	40 1/2	62 1/4	G.			3		Yes.	1, S.A.E.	Buda BTU
4⅛	No.		I	C-P.	Pr.	I	I	S-S.	S-S.	1400	1000	Yes.	F-B.	600–1000	40	900	21	35	41 3/4				3-4	Yes.	Yes.	2-3, S.A.E.	Chief F
4⅛	No.		I	C-P.	Pr.	I	I	S-S.	S-S.	1400	1000	Yes.	F-B.	600–1000	45	925	21	35	41 3/4				3-4	Yes.	Yes.	2-3, S.A.E.	Chief B
4⅜	No.		S.	C-P.	Pr.	I	I	S-S.	I	900	600	Yes.	F-B.	Opt.	40	1150	24	39 3/4	47 1/2	G.			4	Yes.	No.		Climax K
4⅜	No.		S.	C-P.	Pr.	I	I	S-S.	I	900	600	Yes.	F-B.	Opt.	40	1150	24	39 3/4	47 1/2	G.			4	Yes.	Yes.	2, S.A.E.	Climax KU
3⅝	No.		I	Opt.	S-P.	A.	P-S.	I	I	1800	900	No.			28½	450	24½	30 3/8	35	G.			3	No.	Yes.	Own	Continental N
3⅞	No.		I	Opt.	S-P.	A.	P-S.	I	I	2200	900	No.			38	475	24½	30 3/8	35	G.			3	No.	Yes.	Own	Continental N
3⅞	No.		I	C-P.	S-P.	A.	P-S.	I	I	1400	950	No.			35½	580	24½	30 3/8	35	G.			3	No.	Yes.	Own	Continental C2
4⅛	No.		I	C-P.	S-P.	A.	A.	I	I	1600	950	No.			37½	560	24½	30 3/8	35	G.			3	No.	Yes.	2, S.A.E.	Continental C4
4⅛	No.		S.	C-P.	S-P.	A.	A.	I	I	1300	900	No.			44	650	27	32 7/8	41 1/8	G.			3	No.	Yes.	2, S.A.E.	Continental E4
4⅛	No.		S.	C-P.	S-P.	A.	A.	I	I	1300	900	No.			44	660	27	32 7/8	41 1/8	G.			3	No.	Yes.	2, S.A.E.	Continental E7
4	No.		S.	C-P.	Pr.	A.	A.	I	I	1300	900	Yes.	Cent.		55½	1016	27	34 1/2	46 7/16	G.			3	No.	Yes.	1, S.A.E.	Continental B2
3¾	No.		I	C-P.	S-P.	I	P-S.	I	I	2100	800	No.			42	575	24½	27 3/4	39 5/8	G.			3	No.	Yes.	3, S.A.E.	Continental 7W
3½	No.		I	C-P.	S-P.	A.	P-S.	I	I	2000	800	No.			55	600	25 3/4	29 22/32	41 3/32	G.			3	No.	Yes.	3, S.A.E.	Continental 9N
4½	No.		S.	C-P.	S-P.	S-S.	I	I	I	900	800	Yes.	F-B.		35	950	26	33 1/4	45	G.			3-4	Yes.	Opt.	Opt.	Doman
6	No.		S.	C-P.	S-P.	S-S.	I	I	I	700	700	Yes.	F-B.		50	1450	32	42	56 1/4	G.			3-4	Yes.	Opt.	Opt.	Doman
3½	No.		S.	Opt.	C-S.	I	I	I	I			Yes.	Suct.	1000		323	17	22 1/2	33 3/4	G.			3-4	Yes.	Yes.	4, S.A.E.	Elbridge
4	No.		I	C-P.	C-S.	S-S.	I	S-S.	S-S.	1000	600	Yes.	Cent.		35	755–827	23½	35 1/4	40 1/16	G.			4	Yes.	Yes.	3, S.A.	Erd T-TU
4½	No.		S.	C-P.	Pr.	S-S.	I	S-S.	S-S.	950		Yes.	F-B.	900			24	43 1/8	46 1/2	G.			3-4	Yes.	Yes.	1-2, S.A.E.	Erd CA
4½	No.		S.	C-P.	Pr.	S-S.	I	S-S.	S-S.	950		Yes.	F-B.	900			24	43 1/8	46 1/2	G.			3-4	Yes.	Yes.	1-2, S.A.E.	Erd CA
3	No.		I	Th.	S-P.	I	I	I	I	2100	2000	No.			24½	430	27 9/16	28 13/16	38 9/16	G.			3	No.	Yes.	4, S.A.E.	Falls N
3	No.		I	Th.	Pr.	I	I	I	I	2100	2000	No.			25	425	26 1/4	28 13/16	38 7/16	G.			3	No.	Yes.	4, S.A.E.	Falls R
3	No.		I	Th.	Pr.	I	I	I	I	2100	2000	No.			25	425	26 1/4	28 13/16	38 7/16	G.			3	No.	Yes.	4, S.A.E.	Falls R1

(46) **G** = Gear; **C** = Chain.
(47) **S** = Silent.
(48) **A** = Adjustable; **N** = Non-Adjustable.
*Buda crankshafts are of the following diameters:
Models **RU, WU, TU, QU, OU**—Front, 1¾ in.; center, 2 in.; rear, 2⅛ in.
IU, HU, YTU—Front, 2⅛ in.; center, 2¼ in.; rear, 2⅜ in.
ATU, BTU—Front, 2¼ in.; center, 2½ in.; rear, 2⅜ in.
†Wisconsin model RBU crankshaft diameter: Front, 2¼ in.; center, 2 5/16 in.; rear, 3⅜ in.
**Other intermediate crankshaft bearings are of similar length to first intermediate.

Specifications of Stock Engines for Passen

MAKE AND MODEL OF ENGINE	Designed for: (Cars, Trucks, Tractors)	Number of Cylinders	Bore and Stroke	Piston Displacement (Cu. In.)	Cylinders Cast	Is Cylinder Head Detachable?	Valves Placed	Valve Port Diameter (In.)	Valve Lift (In.)	Type of Cam Follower	Volume of Compression Space (Cubic Inches)	Piston Length, In.	Number of Piston Rings	Is Scraper Ring Used?	Weight of Piston with Wrist Pin and Rings (Lb.)	Weight of Connecting Rod (Lb.)	Length of Connecting Rod (C. to C.)	Width of Wrist Pin Bearing (In.)	Diameter of Wrist Pin Bearing (In.)	Width of Connecting Rod Lower End Bearing (In.)	Diameter of Connecting Rod Lower End Bearing (In.)	Diameter of Crankshaft	Number of Crankshaft Bearings	LENGTH OF CRANKSHAFT BEARINGS		
																								Front	1st Int.	Rear
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Field.....C	Tr.....	4	4½x6	381.7	B..	Yes..	H....	2⅛	5/16	R...	41.4	10	3	No..	4.00	5.00	12	2	1¼	2	3	2	3	5	3	5
G. B. & S.....S	C., T., Tr.	4	3¾x4¼	187.7	B..	Yes..	R.....	1⅝	21/64	....	11.7	3⅛	3	Yes.	2.81	1.69	7	1½	⅞	2	1½	1⅝	3	3⅜	2¼	4
G. B. & S.....AA	C., T., Tr.	4	3¾x5	220.9	B..	No..	R.....	1 1/16	21/64	M..	12.7	3¾	3	Yes.	3.06	2.25	10¼	1½	1	2 1/16	1⅞	2¼	3	3	2½	3
Gray.....X	T.....	4	3½x5	192.4	B..	Yes..	H....	1 21/32	5/16	M..	14.3	4 3/32	3	No..	2.64	2.84	9¼	1⅝	⅞	2	1¾	2	3	2¾	2	3⅜
Herschell-Spillman..2700	C., T., Tr.	4	3¼x5	165.9	B..	Yes..	R.....	1 7/16	5/16	M..	9.1	3½	3	No..	2.08	3.00	11	1½	⅞	2	2	2	2	4	...	4
Herschell-Spillman..6500	C., T., Tr.	8	3¼x5	331.8	B..	No..	R.....	1 1/16	11/32	....	9.1	3½	3	No..	2.08	3.16	11	1½	⅞	1 1/8	1⅞	2	3	3	3	3¾
Hercules.....C2	T., Tr....	4	3¾x5⅛	226.4	B..	Yes..	R.....	I. 1⅜, E. 1 11/16	11/32	M..	13.4	4 13/32	4	Yes.	3.75	5.00	11	1¾	1⅛	2¼	2	2	5	2¼	**1¾	3½
Hercules.....CU3	T., Tr....	4	4 x5⅛	257.6	B..	Yes..	R.....	1¾	11/32	M..	14.3	4 13/32	4	Yes.	3.75	5.00	11	1⅞	1⅛	2 1/16	2	2	5	2⅜	**1¾	3⅝
Hercules.....M2	T., Tr....	4	4¼x5½	312.0	B..	Yes..	R.....	1 11/16	11/32	M..	19.0	5⅛	5	Yes.	5.25	6.50	12	1 13/16	1¼	2½	2	2	5	3	**2	4⅜
Hercules.....T	T., Tr....	4	4¾x6	425.3	P..	Yes..	R.....	2⅛	11/32	R...	25.8	6¼	3	No..	6.50	7.50	13¼	2⅛	1⅜	3	2⅜	5	5	2½	**2½	4
Hinkley.....HAA	T., Tr....	4	3¾x5¼	231.9	B..	Yes..	R.....	1¾	5/16	R...	.....	4¾	3	No..	6.44	5.75	11⅛	1¾	1⅛	2¼	2⅛	2¼	3	2¼	3	3
Hinkley.....HAA	T., Tr....	4	4 x5¼	263.9	B..	Yes..	R.....	1¾	5/16	R...	....	4¾	3	No..	6.44	5.75	11½	1¾	1⅛	2¼	2⅛	2¼	3	2¼	3	3
Hinkley.....HA	T., Tr....	4	4½x5½	349.9	B..	Yes..	R.....	2	11/32	R...	....	5¼	3	No..	7.25	7.50	12	1⅞	1¼	2½	2¼	2⅜	3	2½	3½	3½
Hinkley.....B	T., Tr....	4	4 x6	425.3	P..	Yes..	R.....	2⅛	11/32	R...	....	6¼	3	No..	8.00	8.38	13¼	2⅛	1⅜	3	2⅜	2½	3	3	4	4
Lewis.....AAG	C.....	6	3¼x5	248.9	B..	Yes..	R.....	1⅝	5/16	M..	....	4	3	No..	....	....	9½	....	....	....	....	....	....	....	....	..
Light.....H	T., Tr....	4	3¼x4½	149.3	B..	Yes..	R.....	1⅜	7/32	M..	12.7	4½	3	No..	2.00	2.68	9	1½	¾	2	1¾	1⅞	2	2¾	...	2⅞
Lycoming.....K	C., T....	4	3½x5	192.4	B..	Yes..	R.....	1½	13/64	M..	14.37	4	3	No..	2.31	3.12	9½	1 5/16	⅞	2⅛	2	2⅛	2	3 5/16	...	3 5/16
Matthews.....F	C., T., Tr.	4	3½x5	192.4	B..	Yes..	H....	1⅜	I. .254, E. .285	M..	15.8	3¾	3	No..	....	....	9¼	1¾	⅞	2	1¾	2	3	2¾	2	3⅜
North American.....C	T., Tr....	4	3¾x4½	198.8	P..	No...	L.....	1½	5/16	M..	14.5	4½	3	No..	4.25	2.87	8½	2¼	1	2¼	1½	1⅝	3	2¾	2½	3½
North American.....CX	T., Tr....	4	4 x4½	226.2	P..	No...	L.....	1⅝	11/32	M..	16.2	4½	3	No..	4.25	2.87	8½	2¼	1	2¼	1½	1⅝	3	2¾	2½	3½
North American.....D	T., Tr....	4	4⅜x6	360.8	P..	No...	L.....	2⅛	11/32	M..	30.0	6	4	No..	5.81	5.25	11½	2½	1¼	2½	1⅞	2	3	3	3	4
Moline-Knight.....G	C.....	4	4 x6	301.6	B..	Yes..	Sl....	.....	.....	....	20.1	5	3	Yes.	3.12	5.03	13⅜	2⅛	1¼	2½	2¼	3	3	2½	2½	4
Moline-Knight.....W	T.....	4	4 x6	301.6	B..	Yes..	Sl....	.....	.....	....	20.1	5	3	Yes.	3.12	5.03	13⅜	2⅛	1¼	2½	2¼	3	3	2½	2½	4
Moline-Knight.....E	T.....	4	4 x6	301.6	B..	Yes..	Sl....	.....	.....	....	20.1	5	3	Yes.	3.12	5.03	13⅜	2⅛	1¼	2½	2¼	2¼	3	2½	2½	4
Pittsburgh.....84	T.....	4	3 x4½	127.2	B..	Yes..	R.....	1⅛	¼	M..	11.7	4½	3	No..	2.12	2.68	11	1½	33/64	1 17/64	1¼	1 1/16	3	3	2	2 1/16
Red Wing.....AA	Tr.....	4	3¾x4¾	209.9	P..	No...	L.....	1 7/16	.281	....	11.9	4⅛	3	No..	3.50	2.62	8½	1⅛	1 9/16	2⅛	1½	1½	3	3	2¾	3
Red Wing.....F	Tr.....	4	4 1/16x5	259.2	B..	No...	L.....	1¾	9/16	....	19.9	4¾	4	Yes.	4.75	3.62	10½	1¼	1 9/16	2¼	1¾	1¾	3	3½	2¼	4 1/16
Red Wing.....B	Tr.....	4	4½x5	318.1	B..	No...	L.....	1 1/16	9/16	....	27.0	4¾	4	Yes.	5.31	4.12	10⅜	1 13/32	1 9/16	2¼	2	2	3	3½	2¼	4 1/16
Reliable.....EE	Tr.....	2	5 x5	196.3	S..	Yes.	H....	1¾	7/32	R...	23.0	6 3/32	3	No..	12.00	10.50	12½	2	1 3/16	2	2	2	2	3¼	...	4¼
Reliable.....OO	Tr.....	2	6 x6	339.2	B..	Yes.	H....	2⅛	7/32	R...	21.0	7 1/16	3	No..	12.00	10.00	12½	2	1 3/16	2 3/16	2 3/16	2 3/16	2	4½	...	4½
Reliable.....MM	Tr.....	2	9¼x10	1344.0	S..	Yes.	H....	3	7/16	R...	.....	12⅛	5	Yes.	80.00	64.00	21¾	4	2¼	4	4	4	2	6¾	...	8
Rutenber.....38	T., Tr....	4	4 1/16x5½	294.0	P..	No...	R.....	1 7/16	11/32	M..	24.5	5	3	No..	4.18	4.18	12	2	1	2½	2⅛	2⅛	3	3½	3	4½
Rutenber.....40	T., Tr....	4	4 3/8x5½	330.7	P..	No...	R.....	1 7/8	11/32	M..	27.5	5	3	No..	4.37	4.18	12	2	1	2½	2⅜	2⅛	3	3½	3	4½
R & V.....N	Tr.....	4	3½x5	192.4	B..	Yes..	R-H..	1⅝	3/8	M..	14.8	4	3	No..	3.50	4.50	10	1 13/16	1	1¾	2½	2½	2	2½	...	3 5/16
R & V.....D	C.....	6	3¼x4½	224.0	B..	Yes..	L-H...	1⅝	3/8	M..	10.6	3 5/16	3	No..	3.00	3.50	8½	1 1/16	1	1½	2¼	2¼	3	2	3½	3
Supreme.....4C	C., T., Tr.	4	3¼x5	165.9	B..	Yes..	L.....	1¾	7/32	M..	....	4	3	No..	2.00	1.87	10	1 5/16	7/8	2	1 7/8	1 7/8	3	2½	2 1/16	3½
Supreme.....12A	C.....	12	2½x5	294.5	B..	Yes.	In V..	1½	7/32	R...	....	3	3	No..	1.17	1.75	11	1¼	¾	1¼	1 7/8	1 7/8	3	2¾	2 7/8	3¼
Supreme.....12A	C.....	12	2¾x5	356.4	B..	Yes.	In V..	1½	7/32	R...	....	3	3	No..	1.17	1.75	11	1¼	¾	1¼	1 7/8	1 7/8	3	2¾	2 7/8	3¼
Teetor.....19H	C.....	6	3 1/8x5	230.1	B..	Yes..	R.....	1⅜	.343	R...	10.6	3 1/16	3	Yes.	1.93	2.97	9½	1 5/16	1	1 13/16	1⅞	2	3	2⅞	2⅜	3¼
Teetor.....19T	C.....	6	4 1/32x6	572.5	B..	No...	Opt...	2	1/4	....	28.6	5 1/16	5	Yes	3.00	3.75	12	3	1	2¼	1⅞	2	4	4¼	**1 1/16	4
Trego.....100	C.....	6	3½x5	288.6	B..	Yes..	R.....	1 5/16	I. 7/16, E. 9/16	M..	16.0	4	3	No..	....	....	10	2 1/16	1 3/32	1 7/8	2¼	2¼	3	2½	2½	3¼
Trego.....101	C.....	6	3½x5	288.6	B..	Yes..	H....	1 1/16	I. 7/16, E. 5/8	M..	16.0	4	3	No..	....	....	10	2 1/16	1 3/32	1 7/8	2¼	2¼	3	2½	2½	3¼
Universal.....	C.....	4	2 5/8x4	86.6	B..	Yes..	L.....	1⅛	5/16	M..	7.0	3¼	3	Yes.	....	....	7½	1	⅝	1¾	1½	1½	2	2	...	2½
Waukesha.....BX	T., Tr....	4	3¾x5 1/4	231.9	B..	Yes..	R.....	1¾	1/4	M..	22.7	3 7/8	4	Yes.	2.75	5.62	10 5/8	2	1	2¼	2	2	3	2¼	2½	3
Waukesha.....R	T., Tr....	4	4¼x5 3/4	326.3	P..	No...	L.....	2	1/4	R...	26.5	5¼	3	No..	5.00	4.75	11½	2⅛	1¼	2½	2	2	3	2 1/8	3¼	3½
Waukesha.....PU7	T., Tr....	4	4 3/4x6 3/4	478.4	P..	No...	L.....	2⅛	11/32	R...	38.5	5¾	3	No..	6.62	5.87	12¼	2⅝	1½	3	2	2	3	3½	4¼	4½
Weido'y.....MA	T.....	4	3 3/4x5 1/2	242.9	B..	Yes..	H....	1 7/16	1/4	M..	20.3	4 3/8	3	No..	2.90	4.68	12	3½	1	2¼	2	2 1/16	3	2⅜	2½	4
Weidely.....M	Tr.....	4	3 3/4x5 1/2	242.9	B..	Yes..	H....	1 7/16	1/4	M..	20.3	4 3/8	3	No..	2.90	4.68	12	3½	1	2¼	2	2 1/16	3	2 3/8	2½	4
Wisconsin.....QU	T., Tr....	4	3¼x5	165.9	B..	Yes..	L.....	1½	1/4	M..	....	3¾	2	No..	2.22	2.75	10	....	7/16	2	2	2	3	....	3½
Wisconsin.....CAU	T., Tr....	4	3 3/4x5	220.9	B..	No...	L.....	1½	1/4	M..	18.0	5 3/8	3	No..	....	....	10½	1¾	1 3/16	2¾	1¾	1¾	3	2¾	2¾	4
Wisconsin.....EAU	T., Tr....	4	4 x5	251.3	B..	No...	L.....	1½	.313	M..	....	5	3	No..	3.93	4.00	10½	1¾	1 1/16	2¼	1¾	1¾	3	2¾	2¾	4
Wisconsin.....TAU	T., Tr....	4	4 x6	301.6	B..	Yes..	R.....	2 1/32	I. 7/16, E. 9/16	M..	22.9	5 3/8	3	No..	....	....	12	2	1 1/16	3	2	2	4	2½	**2½	3½
Wisconsin.....UAU	T., Tr....	4	4½x6	340.4	B..	....	R.....	2 1/32	I. 7/16, E. 9/16	M..	....	5 1/8	3	No..	4.75	5.81	12	2	1 1/16	3	2	2	4	2½	**2½	3½
Wisconsin.....VAU	T., Tr....	4	4½x6	381.7	B..	Yes..	R.....	2 1/32	I. 7/16, E. 5/8	M..	....	5 1/8	3	No..	5.18	5.81	12	2	1 1/16	3	2	2	4	2½	**2½	3½
Wisconsin.....G	T., Tr....	4	4 3/4x5 1/2	389.9	P..	No...	Opt...	2 1/32	.383	R...	....	6¼	3	No..	6.12	6.87	12	2⅝	1 1/16	3½	2⅜	2⅜	4	3½	**3½	4
Wisconsin.....RAU	T., Tr....	4	4¾x6	425.3	P..	Yes..	R.....	2⅛	3/4	R...	26.2	6	3	No..	....	....	12½	2½	1 5/8	3	2¼	2¼	3	3	3⅞	4
Wisconsin.....RBU	T., Tr....	4	5 x6	471.2	P..	Yes..	R.....	2¼	I. .373, E. .379	R...	40.3	5 11/32	3	No..	....	....	12½	2⅛	1 5/8	3	2¼	†	3	3	3¾	4
Wisconsin.....D	T., Tr....	4	5 1/4x7	606.1	P..	No...	Opt...	2 13/32	.383	R...	....	7	4	No..	8.00	10.68	14	3 1/16	1 9/16	3½	2⅜	2⅜	3	4	4	6
Wisconsin.....M	T., Tr....	4	5 3/4x7	727.1	P..	No...	Opt...	2 13/32	.383	R...	....	6½	4	No..	8.68	10.68	14	3 5/16	1 13/16	3½	2⅜	2⅜	3	4	4	6
Wisconsin.....K	T., Tr....	6	5 1/4x7	909.1	P..	No...	Opt...	2 13/32	.383	R...	....	7	4	No..	8.12	10.68	14	3 1/16	1 13/16	3½	2¾	2¾	4	4	4	6
Wisconsin.....P	T., Tr....	6	5 3/4x7	1090.6	P..	No...	Opt...	2 13/32	.383	R...	....	6½	4	No..	8.68	10.68	14	3 5/16	1 7/16	3½	2¾	2¾	4	4	4	6

Explanation of abbreviations: Numbers in brackets indicate the column to which reference is made.

(1) **C** = Car; **T** = Truck; **Tr** = Tractor.
(5) **B** = Block; **P** = Pairs; **S** = Singly.
(7) **H** = Head; **R** = Right; **L** = Left; **Op** = Opposite; **Sl** = Sleeve.
(10) **R** = Roller; **M** = Mushroom.
(29) **I** = Integral; **S** = Separate.
(30) **C-P** = Centrifugal Pump; **Th** = Thermo-Syphon; **G-P** = Gear Pump; **Opt** = Optional.
(31) **S-P** = Splash-Pressure; **C-S** = Circulating-Splash; **Pr** = Pressure; **N-C** = Non-Circulating Splash.
(32-35) **A** = Aluminum; **I** = Iron; **S-S** = Semi-Steel; **P-S** = Pressed Steel.

ger Cars, Trucks and Tractors (Continued)

Is Cylinder Offset?	If Offset—How Much?	Intake Manifold (Separate or Integral)	Water Circulated by	Lubrication System	Material of Crankcase	Material of Lower Half of Crankcase	Material of Cylinders	Material of Pistons	R.P.M. at which Maximum H.P. is Developed	R.P.M. at which Maximum Torque is Developed	Is Governor Fitted?	If so, what Type?	Governed Speed	Maximum Brake H.P. of Average Product	Weight of Engine Without Ignition or Carbureter (Lb.)	Overall Width of Engine (In.)	Overall Height of Engine (In.)	Overall Length of Engine (In.)	Type of Front End Drive	If Chain, what Type?	Adjustable or Non-adjustable	Points of Engine Support	Adapted for Heavy Fuel	Is Bell Housing Provided?	If so, what No. or Type?	MAKE AND MODEL OF ENGINE
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
No..	..	I.....	C-P...	S-P...	S-S...	I.....	S-S...	S-S...	1000	1000	Yes...	F-B...	750	....	1000	21 11/16	35 7/8	38 3/8	G...	.....	.....	4	Yes.	No..	.....	Field.....C
Yes.	5/8	S.....	Th....	C-S...	I.....	P-S...	S-S...	S-S...	1600	800	Yes...	Suct..	1000	30	450	23 1/2	25	34	G...	.....	.....	3	No..	Yes.	3-5, S.A.E.	G. B. & S.....S
No..	..	S.....	C-P...	Pr....	A.....	A.....	S-S...	S-S...	1700	800	Yes...	Cent..	1400	35	410	23 1/8	31	34 1/16	G...	.....	.....	3	No..	Yes.	3, S.A.E...	G. B. & S.....AA
Yes.	3/8	.....	Th....	S-P...	I.....	Opt...	I.....	.....	1900	950	.....	.....	....	34	495	28	30 5/8	37 1/4	G...	.....	.....	3	Yes.	Yse.	3, S.A.E...	Gray.....X
No..	..	S.....	Th....	S-P...	I.....	P-S...	I.....	I.....	2200	2100	No..	.....	....	43	525	25 3/4	30 1/2	42 7/8	G...	.....	.....	3	No..	Yes.	3-5, S.A.E.	Herschell-Spillman..2700
Yes.	3/8	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	2100	2000	No..	.....	....	70	550	27	31	52 1/16	G...	.....	.....	3	No..	Yes.	3, S.A.E...	Herschell-Spillman..6500
No..	..	I.....	G-P...	Pr....	I.....	I.....	I.....	I.....	1800	1000	Yes...	Cent..	1400	34	650	26 3/4	34 3/16	38 5/16	G...	.....	.....	3-4	Opt.	Opt.	2-3, S.A.E.	Hercules.....C2
No..	..	S.....	C-P...	Pr....	I.....	I.....	I.....	I.....	1800	950	Yes...	Cent..	1400	37	675	24 1/2	30 1/2	41 3/4	G...	.....	.....	3	Opt.	Opt.	S2, .A.E...	Hercules.....CU3
No..	..	I.....	C-P...	Pr....	I.....	I.....	I.....	I.....	1600	800	Yes...	Cent..	1250	41	875	26 3/4	36 1/2	43 7/8	G...	.....	.....	3-4	Opt.	Opt.	2-3, S.A.E.	Hercules.....M2
Yes.	3/8	S.....	C-P...	Pr....	I.....	I.....	I.....	I.....	1400	800	Yes...	F-B..	1000	62	1200	25 3/4	41	46	G...	.....	.....	3	Opt.	Opt.	1-2, S.A.E.	Hercules.....T
No..	..	S.....	C-P...	Pr....	S-S...	P-S...	S-S...	S-S...	2000	900	Yes...	Cent..	1300	35	600	25 1/2	34	36 1/2	G...	.....	.....	3	No..	Yes.	3, S.A.E...	Hinkley.....HAA
No..	..	S.....	C-P...	Pr....	S-S...	P-S...	S-S...	S-S...	1800	900	Yes...	Cent..	1300	40	600	25 1/2	34	36 1/2	G...	.....	.....	3	No..	Yes.	3, S.A.E...	Hinkley.....HAA
No..	..	S.....	C-P...	Pr....	S-S...	P-S...	S-S...	S-S...	1500	900	Yes...	Cent..	1200	45	800	25 1/2	38	43	G...	.....	.....	3	No..	Yes.	2, S.A.E...	Hinkley.....HA
No..	..	S.....	C-P...	Pr....	A.....	A.....	S-S...	S-S...	1400	900	Yes...	Cent..	1050	55	1042	28 3/4	40 3/4	46 3/8	G...	.....	.....	3	No..	Yes.	1, S.A.E...	Hinkley.....B
No..	..	S.....	Opt...	S-P...	I.....	A.....	I.....	I.....	2650	....	No..	.....	....	55	490	.....	....	....	G...	.....	.....	3	No..	Yes.	3-4, S.A.E.	Lewis.....AAG
No..	..	S.....	Opt...	C-S...	I.....	Opt...	S-S...	Opt...	2600	800	Opt...	.....	....	31	365	21 1/8	30	37 1/2	G...	.....	.....	3	Yes.	Yes.	S.A.E.....	Light.....H
No..	..	I.....	Th....	C-S...	I.....	P-S...	I.....	I.....	2100	950	No....	.....	....	35	470	21 11/16	26 7/8	38 1/16	G...	.....	.....	3	No..	Yes.	.....	Lycoming.....K
Yes.	3/8	S.....	Opt...	C-S...	I.....	Opt...	I.....	I.....	2000	1200	Opt...	.....	....	25	450	24 1/4	29 3/8	32 5/16	G...	.....	.....	3-4	No..	Opt.	3, S.A.E...	Matthews.....F
Yes.	3/8	S.....	Opt...	C-S...	I.....	I.....	I.....	I.....	1800	800	No..	.....	....	27	480	26	30	36	G...	.....	.....	3	....	Yes.	3, S.A.E...	North American.....C
Yes.	3/8	S.....	Opt...	C-S...	I.....	I.....	I.....	I.....	1800	800	No..	.....	....	30	480	26	30	36	G...	.....	.....	3	....	Yes.	3, S.A.E...	North American.....CX
Yes.	1/2	S.....	C-P...	C-S...	I.....	I.....	I.....	I.....	2200	800	No..	.....	....	57	800	26	34	41	C...	S...	A...	3	Yes.	Yes.	2, S.A.E...	North American.....D
Yes.	1/16	I.....	Th....	Pr....	A.....	A.....	I.....	I.....	1700	1000	No..	.....	....	53	656	.....	....	....	C...	S...	N...	4	No..	No..	.....	Moline-Knight.....G
Yes.	1/16	I.....	Th....	Pr....	A.....	A.....	I.....	I.....	1700	1000	No..	.....	....	53	695	.....	....	....	C...	S...	N...	3	No..	No..	.....	Moline-Knight.....W
Yes.	1/16	I.....	Th....	Pr....	A.....	A.....	I.....	I.....	1700	1000	No..	.....	....	53	725	.....	....	....	C...	S...	N...	4	No..	No..	.....	Moline-Knight.....E
No..	..	S.....	Th....	N-C..	I.....	P-S...	I.....	I.....	1800	1100	No..	.....	....	18	375	22 1/2	29	32	G...	.....	.....	3	No..	Yes.	Opt.....	Pittsburgh.....84
Yes.	3/8	S.....	C-P...	C-S...	I.....	I.....	I.....	I.....	....	....	Yes...	Cent..	1000	19	490	19 1/16	30 5/16	33 3/4	G...	.....	.....	4	.....	.....	.....	Red Wing.....AA
No..	..	I.....	C-P...	C-S...	I.....	I.....	I.....	I.....	....	....	Yes...	Cent..	950	22	560	20 3/8	28 1/2	36 1/4	G...	.....	.....	4	.....	.....	.....	Red Wing.....F
Yes.	1/8	I.....	C-P...	C-S...	I.....	I.....	I.....	I.....	....	....	Yes...	Cent..	900	26	600	20 7/16	28 3/8	36 1/4	G...	.....	.....	4	.....	.....	.....	Red Wing.....B
Yes.	1/32	S.....	Opt...	Pr....	I.....	I.....	S-S...	S-S...	600	....	Yes...	F-B...	600	13	650	24 5/8	21 3/8	50 7/8	.....	.....	.....	..	Yes.	.....	.....	Reliable.....EE
No..	..	S.....	C-P...	Pr....	I.....	I.....	I.....	I.....	600	....	Yes...	F-B...	600	22 1/2	785	26 3/4	24 5/8	54	.....	.....	.....	..	Yes.	.....	.....	Reliable.....OO
Yes.	1/32	S.....	Opt...	Pr....	I.....	I.....	S-S...	S-S...	350	....	Yes...	F-B...	380	51	3650	44 7/8	39 7/8	99 1/2	.....	.....	.....	..	Yes.	.....	.....	Reliable.....MM
No..	..	S.....	C-P...	Pr....	I.....	I.....	I.....	I.....	2000	1000	Opt...	.....	1000	31	800	27	35	43 1/4	G...	.....	.....	3	Yes.	Opt.	3, S.A.E...	Rutenber.....38
No..	..	S.....	C-P...	Pr....	I.....	I.....	I.....	I.....	2000	1000	Opt...	.....	1000	34	800	27	35	43 1/2	G...	.....	.....	3	Yes.	Opt.	3, S.A.E...	Rutenber.....40
No..	..	I.....	Th....	Pr....	I.....	I.....	I.....	I.....	2000	1000	No..	.....	....	34	691	19	39	38	G...	.....	.....	....	No..	No..	.....	R & V.....N
No..	..	I.....	Th....	Pr....	I.....	P-S...	I.....	I.....	2670	1100	No..	.....	....	57	727	28 1/4	33 5/8	49 11/16	G...	.....	.....	3	No..	Yes.	3, S.A.E...	R & V.....D
Yes.	5/8	I.....	Opt...	S-P...	Int...	P-S...	I.....	I.....	2150	1600	No..	.....	....	42	360	18 1/2	28	33 1/4	G...	.....	.....	3	No..	Opt.	.....	Supreme.....4C
No..	..	S.....	C-P...	S-P...	A.....	A.....	Opt...	Opt...	....	....	.....	.....	....	....	.....	21	31	43 7/8	C...	S...	A...	3	No..	Yes.	3, S.A.E...	Supreme.....12A
No..	..	S.....	C-P...	S-P...	A.....	A.....	Opt...	Opt...	....	....	.....	.....	....	....	.....	21	31	43 7/8	C...	S...	A...	3	No..	Yes.	3, S.A.E...	Supreme.....12A
No..	..	I.....	C-P...	S-P...	Int...	I.....	I.....	I.....	2300	1300	No..	.....	....	43 1/2	524	17 3/4	24 11/16	38 11/16	G...	.....	.....	3	No..	Yes.	3, S.A.E...	Teetor.....19H
No..	..	I.....	C-P...	S-P...	A.....	A.....	I.....	A.....	1900	1050	No..	.....	....	85	.....	24	28	45	G...	.....	.....	4	No..	No..	.....	Teetor.....19T
No..	..	I.....	C-P...	Pr....	A.....	A.....	I.....	I.....	2400	1300	No..	.....	....	65	.....	25 3/4	30	52	G...	.....	.....	3	No..	Yes.	3, S.A.E...	Trego.....100
No..	..	I.....	C-P...	Pr....	A.....	A.....	I.....	I.....	2400	1300	No..	.....	....	65	.....	25 3/4	33 1/2	52	G...	.....	.....	3	No..	Yes.	3, S.A.E...	Trego.....101
No.	..	I.....	Th....	N-C..	I.....	I.....	I.....	I.....	1500	1200	Yes...	Cent..	Opt.....	10	300	12	16	22	G...	.....	.....	3	Yes.	No..	.....	Universal.....
No..	..	I.....	C-P...	C-S...	A.....	I.....	S-S...	S-S...	1800	900	Yes...	Own..	1150	28	500	20 3/8	29	36 3/4	G...	.....	.....	3	Yes.	Opt	3, S.A.E...	Waukesha.....BX
Yes.	1/2	S.....	C-P...	C-S...	A.....	I.....	S-S...	S-S...	1200	800	Yes...	Own..	900	32	600	20 3/8	33 1/2	37 1/4	G...	.....	.....	4	Yes.	Opt.	2, S.A.E...	Waukesha.....R
Yes.	1/2	S.....	C-P...	C-S...	A.....	A.....	S-S...	S-S...	1200	500	Yes...	Own..	800	45	850	23 3/4	34	44	G...	.....	.....	3	Yes.	Yes.	1, S.A.E...	Waukesha.....PU7
No..	..	I.....	C-P...	S-P...	S-S...	I.....	S-S...	S-S...	1600	....	Opt...	.....	....	32	.....	25 3/4	32	40	G...	.....	.....	3	Yes.	Yes.	3, S.A.E...	Weidely.....MA
No..	..	I.....	C-P...	S-P...	S-S...	I.....	S-S...	S-S...	1600	....	Yes...	Cent..	Opt...	32	750	24 5/16	32	39 1/16	G...	.....	.....	4	Yes.	No..	.....	Weidely.....M
No..	..	S.....	C-P...	C-S...	I.....	A.....	I.....	I.....	1700	1000	No..	.....	....	25	435	17 3/4	27 1/2	33 3/8	G...	.....	.....	3	Yes.	Yes.	3, S.A.E...	Wisconsin.....QU
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1650	900	Opt...	.....	1000	31	450	20 3/4	31 1/16	40 1/16	G...	.....	.....	3	Yes	Yes	.3S.A.E..	Wisconsin.....CAU
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1600	1000	Opt...	.....	1000	37	460	20 3/4	31 7/8	40 1/16	G...	.....	.....	3	Yes.	Yes.	3, S.A.E...	Wisconsin.....EAU
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1600	900	Opt...	.....	1000	45	650	21 1/16	34	46 1/16	G...	.....	.....	3	Yes.	Yes.	3, S.A.E...	Wisconsin.....TAU
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1600	900	Opt...	.....	1000	50	660	21 1/16	34	46 1/16	.....	.....	3	3	Yes.	Yes.	3, S.A.E...	Wisconsin.....UAU
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1600	900	Opt...	.....	1000	55	670	21 1/16	34	46 1/16	G...	.....	.....	3	Yes.	Yes.	3, S.A.E...	Wisconsin.....VAU
Yes.	3/4	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1700	900	Opt...	.....	1000	75	1000	23 3/8	33 1/2	56 3/4	G...	.....	.....	4	....	No..	.....	Wisconsin.....G
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1600	900	Opt...	.....	1000	60	790	23 7/8	37 1/2	48 3/4	G...	.....	.....	3	Yes.	Yes.	3, S.A.E...	Wisconsin.....RAU
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1600	900	Opt...	.....	1000	65	800	23 7/8	37 1/2	48 3/4	G...	.....	.....	3	Yes.	Yes.	3, S.A.E...	Wisconsin.....RBU
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1400	900	Opt...	.....	Opt.....	75	890	24 1/2	36 11/16	48 3/4	G...	.....	.....	4	Yes.	No..	.....	Wisconsin.....D
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1400	900	Opt...	.....	Opt.....	90	900	24 1/2	37	48 3/4	G...	.....	.....	4	Yes.	No..	.....	Wisconsin.....M
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1400	800	Opt...	.....	900	105	1200	26	37 3/8	68 7/8	G...	.....	.....	4	Yes.	No..	.....	Wisconsin.....K
No..	..	S.....	C-P...	Pr....	A.....	A.....	I.....	I.....	1400	800	Opt...	.....	900	125	1275	26	37 3/8	68 7/8	G...	.....	.....	4	Yes.	No..	.....	Wisconsin.....P

(46) **G** = Gear; **C** = Chain.
(47) **S** = Silent.
(48) **A** = Adjustable; **N** = Non-Adjustable.
*Buda crankshafts are of the following diameters:
Models **RU, WU, TU, QU, OU**—Front, 1¾ in.; center, 2 in.; rear, 2⅛ in.
IU, HU, YTU—Front, 2⅛ in.; center, 2¼ in.; rear, 2⅜ in.
ATU, BTU—Front, 2¼ in.; center, 2½ in.; rear, 2⅝ in.
†Wisconsin model RBU crankshaft diameter: Front, 2¼ in.; center, 2 5/16 in.; rear, 2⅞ in.
**Other intermediate crankshaft bearings are of similar length to first intermediate.

Two-Stroke Engines for Motorcycles*

An Outline of Their Advantages and Disadvantages and a Description of a Design Due to the Author

By E. Tilston

UP to the present time the two-stroke type of engine has been used only for lightweight motorcycles and small motor boats—except in the case of engines of the Diesel and hot-bulb types. The present type of three-port two-stroke engine gives about one-third more power than the four-stroke engine for the same size of cylinder with the engine revolving at normal speeds, although the power curve falls away more rapidly than with the four-stroke engine at abnormal speeds.

Seeing that the two-stroke engine gives more power than the four-stroke, the former can be made smaller for the same horsepower, and consequently the piston is reduced in size, and the connecting rod made shorter on account of the difference in length of stroke. With two cylinders the superiority of the two-stroke engine is more pronounced in torque, balance and absence of vibration. No one has yet been foolish enough to adopt a twin-cylinder vertical four-stroke engine for motorcycles (although its torque is far superior to the Vee type), for the reason that the balance is inferior. The only two-cylinder four-stroke engine with good torque and balance is the horizontal twin-cylinder, but even this cannot be placed alongside the two-cylinder two-stroke engine with the power stroke taking place simultaneously at the two opposite ends, which not only balances the thrust on the bearings, but considerably reduces wear and tear. Although the horizontal twin-cylinder type is admirable in balance and torque in both engines, the author does not consider either a good proposition in a motorcycle on account of frame design.

This question of torque, balance and vibration brought about the demise of the one- and two-cylinder vertical four-stroke engine in motor cars, and the author is of the opinion that history will repeat itself in the motorcycle. If it is necessary to adopt an engine in a motor car which gives a propelling force every stroke, how much more necessary is it in the motorcycle where there is so little room for springing to minimize vibration? With regard to torque, the two-cylinder vertical two-stroke engine is in every way equal to the four-cylinder four-stroke engine, although the balance may not be so good, but as one piston is descending while the other is ascending, what little difference there is in balance through the couple is offset by halving the number of cylinders and reducing the reciprocating parts.

Simplicity and Lower Cost Excellent Advantages

The greater simplicity and lower cost of the two-stroke engine are excellent advantages from a production point of view. Providing that carburetion is the same in both types of engine, the double-firing stroke will give the best result in starting, especially if this is coupled with half the weight of reciprocating parts.

Much attention has been given of late to improving the carburetion in connection with the four-stroke engine by exhaust jacketing the inlet pipe. This is obtained in the two-stroke engine without any inaccessible pipes, as the charge entering the crankcase is heated, which has a further tendency to keep the engine cool.

Accessibility—another point in which the two-stroke engine excels—not only adds to the cleanliness of the machine, but also to its appearance, which is a desirable feature when selling. If accompanied by simplicity it is a great inducement to the novice who is about to purchase a motorcycle, and there can be no doubt that it is a very big factor in increasing the army of motorcyclists.

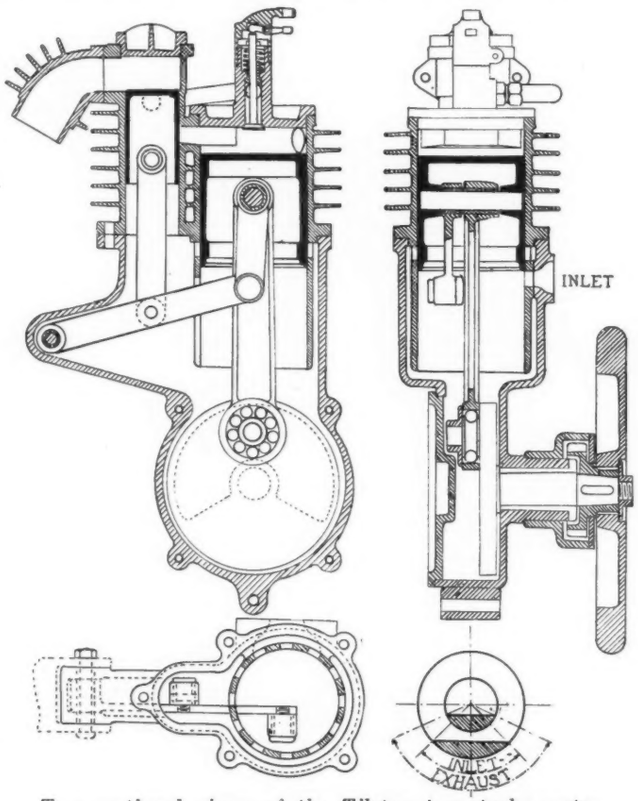
It is only necessary to consider the simplicity of the two-stroke engine with its absence of valves, and then to turn to the timing case of the four-stroke engine, which needs constant adjustment, to realize what scope a designer has in making the two-stroke engine accessible.

Best Type of Engine for Frame Design

The two-stroke engine appears to be the best type for frame design, inasmuch as character of torque and balance (which minimize vibration), total weight, and weight of reciprocating parts are in its favor.

Just as one- and two-cylinder engines in motor cars were discarded on account of inferior torque, so there will be a tendency towards multiple cylinders in motorcycle design. It appears impossible to make a two-cylinder four-stroke engine of even torque and good balance unless the cylinders are placed at 180 deg. The horizontal twin-cylinder arrangement in either type of engine—as previously mentioned—does not lend itself to frame design, while there are other disadvantages in cooling, if the engine is placed with the flywheel revolving in the direction of the road wheels.

Frame design is a most important matter, and the public—especially those who are familiar with frame breakages during the war—will look with suspicion in future on the machine that lets them down. The author admits that bad springing is responsible for a good many frame breakages, but there is also the question of best type of engine in designing a good frame without adding unnecessary length.



Two sectional views of the Tilston two-stroke motorcycle engine, with piston type exhaust valve

*From a paper presented to the Institution of Automobile Engineers, London.

In regard to weight the advantage lies with the two-stroke engine. A saving in weight is a saving in cost, and is of enormous benefit in case of an accident which necessitates the machine being pushed home. There is also a considerable saving in the wear and tear on tires.

Reliability

There can be no doubt that the present-day two-stroke engine is very unreliable for large horsepowers. In the first instance it is necessary to bear in mind that there are two power impulses against one in the four-stroke engine, consequently the moving parts, especially the piston and small end of the connecting rod, are more likely to get overheated. This is counterbalanced to a certain extent by the fact that a new cool carbureted charge is drawn into the crankcase every revolution, which lies inside the piston, and tends to keep these parts cool. In the present-day two-stroke engine there are other reasons for overheating, namely, the exhaust port is arranged at the lower end of the cylinder, and the hot burnt gases do not tend to escape, consequently the piston in ascending is subject to the heat from the exhaust. It must be admitted that even in small two-stroke engines of 250 c.c. it frequently happens that the engine peters out on a fast run of 50 miles or so. For further proof of the evil effect of exhausting at the lower end of the cylinder, it is only necessary to examine the top piston rings on the exhaust side of any two-stroke engine, and they will be found caked up with carbon, and often require cutting out after a few hundred miles' run. To sum up, the disadvantages of exhausting at the lower end of the cylinder are as follows:

Loss of incoming charge through the exhaust, imperfect scavenging, overheating of the piston, which is increased by the deflector, and caking of piston rings with carbon on the exhaust side, all of which add considerably to unreliability and waste.

Economy

The small difference in economy of fuel between the present-day two-stroke engine and the four-stroke engine is no doubt due to the loss of incoming charge through the exhaust, combined with the large amount of burnt gases in the cylinder. Remove these two evils, and there is no reason why the two-stroke engine should not equal the four-stroke engine as regards economy.

It would naturally be imagined that the two-stroke engine would be more flexible than the four-stroke engine, seeing that a single-cylinder two-stroke engine is equal in power impulses to a two-cylinder four-stroke engine, and there can be no question but that by increasing the number of cylinders flexibility is improved. In the author's opinion, the reason why the two-stroke engine is actually not more flexible than the four-stroke engine is that there is a greater amount of exhaust gas left in the cylinder on the compression stroke than is found in the four-stroke engine. If all the exhaust gases can be ejected from the cylinder, at every position of throttle opening, the flexibility would increase in proportion to its superior torque.

In the two-stroke engine there are no valves, which are generally the source of heating troubles in the four-stroke engine. If the cylinder is scavenged from end to end, and the exhaust removed to the top end of the cylinder, with a flat-topped piston, the author is of opinion that the two-stroke engine will give less trouble in overheating than the four-stroke engine, provided that the means for controlling the exhaust are as efficient from a cooling point of view as the other parts of the engine.

Desirable and Undesirable Features

Undesirable

The deflector on the top of the piston.
The exhaust at the lower end of the cylinder.
Valves—they must not give trouble through overheating.
The waste of the incoming charge through the exhaust.

Desirable

The cylinder scavenged from end to end through a ring of ports and an annulus.
A light flat-topped piston.
The incoming charge must fill the cylinder completely with the throttle full open.
No exhaust left in the cylinder at any position of the throttle.
Both inlet and outlet must be unobstructed to allow free passage, otherwise back pressure of the outgoing exhaust prevents the new charge entering, and diffusion of the two results in escape of the new charge through the exhaust. If these ideals are accomplished, it is possible to more than double the power as compared with the four-stroke engine for the same c.c.

The combustion space represents roughly 20 per cent of the cylinder volume, and if this could be filled with a new charge and fired twice, as compared with the combustion space in the four-stroke engine, which is filled with burnt gases and fired once, then the possibility of increasing the power of the two-stroke engine may be more than doubled.

The two-stroke engine that the author is responsible for is the result of very careful consideration of the merits and demerits of both types of engines on the lines laid down.

When the first experimental engine was demonstrated at Stonebridge several criticized it on account of its cost and extra moving parts as compared with the ordinary two-stroke engine. However, it is impossible to control an exhaust port at the top end of the cylinder and provide an extra pump for displacement without additional moving parts and expense. It will be noticed that the means to control the exhaust port (the piston valve) also gives additional displacement to induce sufficient charge into the crankcase from the carbureter, which the movement of the piston alone fails to accomplish.

The lower end of the piston and piston valve are both open to the crankcase and, as they move upwardly together, their combined displacement is available to fill the cylinder at the end of the next downward stroke of the piston. On the explosion stroke, the closing of the port from the carbureter to the crankcase first occurs, followed by compression of the charge in the crankcase. The opening of the exhaust at the top end of the cylinder follows, and shortly afterward the inlet ports from the crankcase to the cylinder are opened by the main piston.

An exhaust poppet valve overheats, but with a piston valve as shown this type of engine does not get nearly so hot as the three-port two-stroke engine without valves.

When the explosion takes place the piston valve is at the top of its stroke and is considerably above the combustion space. The cool carbureted charge, introduced into the crankcase every revolution, lies not only inside and around the main piston, but also inside the piston valve, and as there is only a thin wall of metal separating the hot explosion from the newly introduced cool charge, the excessive heat from the former is absorbed by the charge, which is afterward passed into the cylinder, thus cooling the piston valve and preventing dissipation of heat from the outside. This helps the fuel consumption and aids in an easy start.

There are no rings on the piston valve, which is of the same metal as the cylinder. A clearance of 0.001 in. is allowed between the bore and the valve, and the short stroke of the valve, in conjunction with the cooling effect of the charge lying inside, allows the temperature from end to end of the valve to be maintained practically constant, thereby permitting free movement without fear of seizing.

The top rings of the main piston maintain their elasticity under severe loads and constant running because the piston is cooled internally every revolution. The piston valve is operated by link motion from the piston pin, with about half the stroke of the main piston. There are several ways in which the piston valve can be reciprocated, but the design shown allows the crankcase volume to be cut down with a view to increasing the compression.

It will be noticed that the compression release valve in the cylinder head is so arranged that the passage from the cylinder is in communication with the upper end of the piston valve cylinder. Just before the explosion occurs, the piston valve has moved up and prevented an explosion occurring in the exhaust pipe and muffler, and a very simple and effective method of lowering the compression is obtained, which facilitates easy starting.

The Economics of Flight

Effect of Altitude of Flight on the Energy Expenditure Necessary to Cover a Given Distance—Problem Involves a Consideration of Many Factors

By H. B. Irving

DURING the war the economics of flying was of no importance as far as fighting in the air was concerned. It had to be considered seriously in connection with long-distance air raids, when it was of great importance to cover the longest possible distance on the minimum of gasoline, and for reconnaissance also the economics of flying deserved attention.

But with the end of the war this subject appears in a quite different light. Now the question of cost of transport enters in largely, whereas, during the war the question of cost was scarcely considered. The problem in commercial aviation is to transport goods or passengers at the cheapest rate at which it is possible to run a service which will offer sufficient advantages over existing services to be able to compete with or replace them.

It is the object of the present article to give a brief consideration of the aerodynamic principles which govern the economics of flying without entering into the multitude of other considerations which affect the question. The aerodynamic principles are perfectly general, while the other considerations are usually of a particular nature and need special application to each case.

Aerodynamically the economics of flight is concerned with the effect of the various conditions of flight on the energy required to carry a given weight a given distance. Take first of all the case of a given body whose resistance is $P\rho V^2$, where K is a constant, ρ is the density of the air, and V is the speed through the air. The fact that K is constant of course implies that the resistance of the given body varies as the density of the air and as the square of the speed. The former assumption is always true, while the latter is generally very nearly true. The energy required to move the body through distance S at speed V varies as RS or $K\rho V^2S$.

Two very important general principles are at once apparent from the above reasoning. First, the energy required to transport a body a given distance varies as the square of the speed at which it is moved. This is true in spite of the fact that the greater the speed the less the time required. So that the lower the speed of flight the more economical is the flight. This conclusion shows the fundamental disability under which high-speed flight labors in comparison with other means of transport, and it is only modified in practice by the fact that "time is money."

The second conclusion depends upon the common knowledge that the density of the air decreases with increasing altitude. At 10,000 ft., for instance, the density is 0.722 that at ground level, and at 20,000 ft. it is only 0.520 the density at ground level. It would appear to follow, therefore, that on general grounds, for economic flight the altitude of flight should be as great as possible. In practice the limit imposed on the altitude of flight is due to the reduction in power of the engine caused by the rarefaction of the air at altitudes and (or) the personal physical disabilities caused by the atmospheric conditions at high altitudes. To some extent the former limitation can be overcome by designing the engine specially for performance at altitudes, and the latter may also be partially overcome by suitable provision being made, but it would hardly appear at present that any provision for the physical needs, due to very high altitudes, of either pilot or passengers could form part of any commercial flying enterprise, and that there is, therefore, practically speaking, a limit to the altitude at which commercial flight can take place.

Proceeding now from the case of a plain body whose resistance varies as V^2—the case of the airship—to the case of the airplane it must be remembered that, in general, the altitude at which the airplane flies varies according to the speed of flight and that the foregoing reasoning only applies to flight at a given altitude. With the alterations in attitude which take place in practice the resistance coefficients of the body, struts, wires, etc., of the airplane generally alter very little, while the lift and drag coefficients of the wings both alter greatly. The

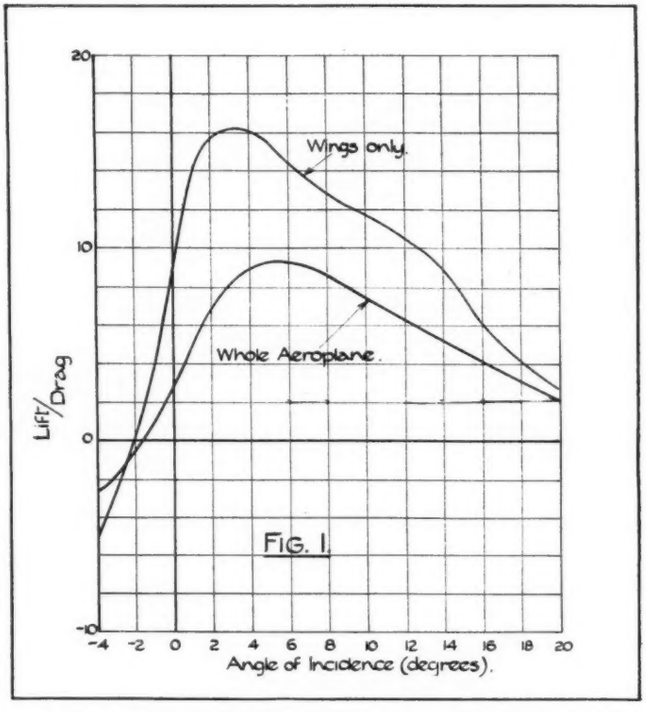


Fig. 1—Diagram showing variation of lift drag ratio with angle of incidence

total lift must, of course, remain equal to the total weight throughout the flight, so that as the attitude alters the speed must alter, an increase in the lifting power of the wings caused by increasing their angle of attack being accompanied by a decrease in the speed of the machine.

The ratio of the lift to the drag of a machine is one of its most important characteristics. Other things being equal, the greater this ratio the greater the aerodynamic efficiency of the airplane. For a given airplane the ratio has a definite value for each attitude of flight. Fig. 1 shows the general nature of the curve of lift-drag ratio plotted against angle of incidence of wings for a biplane. Two curves are given, one for the wings only and one for the whole machine. Such curves are generally derived from the results of experiments on models placed in a wind tunnel.

It will now be shown that the most economical speed of flight for any given airplane is that for which the attitude is the one corresponding to maximum lift-drag ratio for the whole machine. The work done in moving an airplane a distance S (relative to the air) when the resistance is D is equal to DS. If $W = L =$ weight of airplane, we have

$$DS = \frac{W}{L/D} \times S$$

and for a given distance S this is a minimum when L/D is a maximum. So that the most economical attitude for flight is that corresponding to maximum lift-drag ratio of the airplane, which attitude is generally not much different from that for maximum lift-drag ratio of the wings.

The above conclusion is true for any altitude, a fact which means that, aerodynamically, that there is nothing to be gained by flight at high altitudes with a given airplane. Other considerations, however, have to be taken into account in this connection. Suppose an airplane to be flying at its most economical altitude. In order that the lift of the wings may at all altitudes be equal to the weight of the machine the forward speed must vary inversely as the square root of the density of the air. Since lift and lift-drag ratio are constant the drag must be constant, and therefore the horsepower must vary with density in the same way as the forward speed; that is, the horsepower varies inversely as the square root of the density. From this reasoning two points emerge, each indirectly bearing on the economy of flight and showing why flight at the higher altitudes is preferable to flight just above ground, although aerodynamically the economy of flight is the same at all altitudes. Firstly, since the forward speed increases with altitude, there will be a saving of time by flying at the higher altitude, a very important consideration. And secondly, since the power required increases with altitude, as shown above, it will pay to fly at an altitude which utilizes or nearly utilizes the full power of the motor, since motors generally run most economically at about their full power.

Another method of considering the question of the best speed for economic flight of a given airplane is as follows:

Work done in moving airplane through distance

$$S = DS = \frac{DV}{V} \times S$$

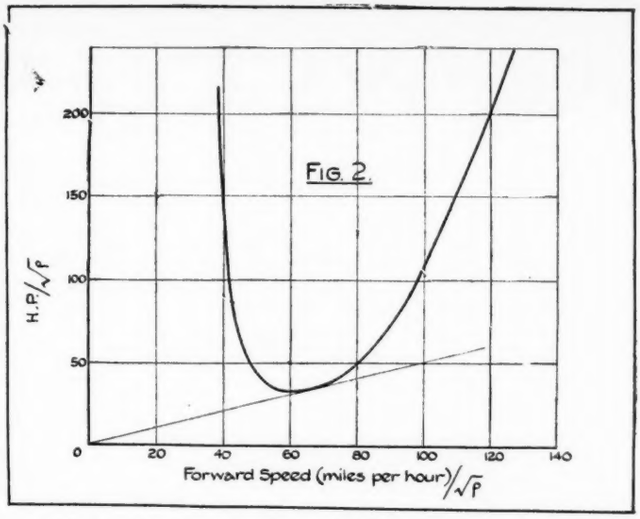


Fig. 2—Diagram for determining most economical speed of flight

That is, the work done varies as $\frac{\text{H.P.}}{V} \times S$ and is a minimum for a given distance when the ratio H.P./V is a minimum. This condition is illustrated by Fig. 2, in which H.P./$\sqrt{\rho}$ is plotted against $V/\sqrt{\rho}$, where ρ is the density of the air relative to the density at ground level. The figure thus applies to any altitude, change in density being allowed for by change in the scales of the coordinates of the curve. The most economical speed is found by drawing a tangent from the origin to the curve, and it will be seen that the most economical speed is only slightly greater than the speed for minimum horsepower. Thus, an airplane flying at its "ceiling" is flying at very nearly its most economical altitude.

It has now been shown that for a given airplane aerodynamically the maximum economy of flight is the same at all altitudes, but that this involves flight at speed varying according to the altitude. If the economy of flight of a machine of given weight is considered—as it should be—*for a given speed*—the problem as to the effect of altitude on economy becomes rather different. For economical flight the altitude must be always the same, namely that of maximum lift-drag ratio; therefore, if the speed is to be constant, the area of the wings must vary inversely as the density. But in spite of this fact, the resistance of the wings remains the same at all altitudes, since

$$D_w = \frac{W}{L/D_w}$$

where L/D_w is the lift-drag ratio for the wings. The size of the body remaining the same, its resistance will vary as the density and hence there will be a saving of power in the machine specially designed to fly at high altitudes.

To some extent this conclusion is modified by the fact that the machine which flies at the higher altitude has larger and therefore heavier wings, struts, etc., so that the *useful load* carried by this machine will be rather less than that carried by the machine flying at the lesser altitude; and, further, the larger wings mean more re-

Table Showing Economy of Power Due to Flight at High Altitude

Height in feet	0	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000
Relative density ρ	1	.940	.870	.825	.772	.722	.678	.636	.596	.556	.520
Resistance of Body, etc. $R = 200 \times \rho$	200	188	174	165	154	144	135	127	119	111	104
Total resistance $= R + 200$	400	388	374	365	351	344	335	327	319	311	304
Percentage Reduction on resistance at ground level	0	3	6.5	8.75	11.4	13.9	16.1	18.2	20.2	22.2	24.0

sistance other than wing and body resistance. But the weight of the wings and the resistance of parts other than wings which varies with wing area are each only a small proportion of the total weight and resistance, and the economy to be gained by designing for high altitude at a given speed is nevertheless considerable.

It is not possible in the present article to give any exact figures as to the magnitude of the saving which could be effected by designing for high altitudes. This would depend—among other things—on the type of airplane and the forward speed desired. In fact, in order to arrive at accurate figures in any particular cases would practically mean roughing out weights and resistances for each special design. A rough idea as to the order of magnitude of the saving may, however, be arrived at by some very simple calculations for a particular case. Take, for example, an airplane of weight 3200 lb., say, whose lift-drag ratio at ground level is 16 for the wings only and 8 for the complete machine. The resistance at ground level will then be 200 lb. for the wings and 400 lb. for the complete machine, thus making the resistance of the body, etc., 200 lb. The accompanying table shows the percentage saving in resistance (and consequently horsepower, since the forward speed is supposed constant) over that at ground level at altitudes up to 20,000 ft. In this particular case, in which at ground level the resistance of the body, etc., is equal to half the total resistance of the airplane, the percentage reduction in total resistance at any particular altitude is equal to half the percentage reduction in the density at that altitude. The condition that the resistance of the body, etc., is equal to half the total resistance will in general not be very far from being realized in practice, and so the figures of the table give an indication of the order of magnitude of the saving which may be effected by designing specially for altitude. It will be noticed that the figures of the table are independent of the forward speed, and in this connection there are two points which should be remembered. They are the questions of landing speed and rate of climb. The airplane designed to fly at its most economical altitude and to use its full power at ground level would, as Fig. 2 shows, require only very slightly less horsepower at the altitude for minimum horsepower. There would thus be only a very small reserve of power for climbing and the ratio of climb would be very slow indeed. Again, with the machine designed for flight at ground level the forward speed is strictly limited to values which are not very high in order to keep the landing speed down. The maximum lift coefficient of wing section is generally about double its value at the altitude for maximum lift-drag ratio; which means that the landing speed is about equal to the economical speed divided by $\sqrt{2}$. Thus, if the chosen speed of flight is 100 miles per hour the landing speed is equal to 71 m.p.h., a value which is considerably on the high side.

But consider now the airplane which is designed for the same forward speed at an altitude of 8000 ft., say. Its landing speed will now be reduced from 71 m.p.h. to 71×0.772, or nearly 54.5 m.p.h., and the rate of climb at ground level will now be of fair magnitude. For the horsepower required for the 8000-ft. machine when at ground level will be $\sqrt{2}$ times that required at 8000 ft., that is, 5.7 per cent of the power will be available for climb. In the case of the particular airplane chosen as example, this would give a rate of climb of 111 ft.-min.

Obviously, then, machines designed for economical flight at low altitudes are not practical machines, and the effect of altitude on economy of flight should be considered by comparing the performances of machines at high altitudes with those for altitudes of perhaps 6000 to 8000 ft.

Kessler Super-Charge Engine Developed for Automobile Purposes

(*Continued from page* 1293)

uses a counter-balanced crankshaft, and this same type of counter-balancing will be used on the 3¾ by 3¾-in., six-cylinder automobile engine, of which sample engines are now being made up. Air by-passages are so arranged that every down stroke of the piston is utilized for producing crankcase compression. As compared with the normal form of engine, it will be slightly higher, due to the increased combustion chamber volume. The weight per unit of displacement will probably run about the same as that of the ordinary type of engine, and in general appearance there will be no marked difference. The automobile type should weigh approximately 5.3 lb. per hp.

A representative of AUTOMOTIVE INDUSTRIES saw an aviation type Kessler engine on the block, operating first as a normal poppet valve type and then with the super charge admitted. The difference was remarkable, for, although the valve timing was a little early in the intake cut-off for the ordinary poppet type engine, yet it gave a very creditable performance. As soon as the supercharge was admitted, however, the speed of the engine rose remarkably, and it was possible to carry a much higher load on the engine. While it is impossible for the representative of AUTOMOTIVE INDUSTRIES who witnessed the test on the engine to accurately state the results of the cushioning effect on the bearings due to crankcase compression, it is positive that on the old automobile type engine employed in the experimental car the vibration is remarkably low for a four-cylinder engine of any type. Claims made by the inventors of this engine and taken seriously by car makers who have examined it, state that bearing life is materially increased by the effect of the cushion.

The engine now being developed for car work will have a proportional valve capacity which is probably the largest ever used in automobile practice. It will have two intakes and two exhaust valves per cylinder, each valve having 1½ in. clear diameter, although the bore of the engine is only 3¾ in.

Glued Part Failures Not Always Due to Glue

GLUES are often blamed for failures for which they are not responsible. Tests made at the Forest Products Laboratory of the U. S. Forest Service at Madison, Wisconsin, show that properly handled commercial glue develops a shearing strength greater than that of most woods.

The average glue user prepares his glue with reasonable intelligence but commits atrocities in preparing surfaces to be glued and in handling pieces after gluing. To get full strength from any glue, proper surface contact is imperative. Good glue will adhere fairly well even with poor surface contact. Joints of this kind possess, however, inherent weakness and the added disadvantage that they are more liable to ruin through bacterial action than tight joints, since the glue in them is more exposed.

The proper application of pressure is important in all glued work, but doubly so in the manufacture of plywood. Securing proper pressure involves keeping cauls and press in first-class condition and using them skillfully.

Tractor Design from the Operator's Viewpoint

Criticism and Suggestions Based on Extensive Tractor Experience on Large Western Ranches

By Arthur B. Domonoske

IN the following article I am giving the side of the design as the operator looks at the result and not as the designer must necessarily do in laying out the machine. Shop practice must guide the designer to a large extent, while to the operator the necessity of keeping the machine running is the paramount consideration. My experience has been mostly in the Far West and with the track-laying type of machine, so I shall confine my attention to that locality and to that type of machine.

As a foreword it might be well to mention that on the western ranches the tractor has been adopted not for any inherent love for machinery on the part of the rancher, nor because of the glib talk of the salesman, but of dire necessity. With the increase of wages and the shortening of hours in the cities, the better men of agricultural communities drifted into city trades and occupations.

The hours on the ranches were long, the sleeping accommodations were poor, no provision was made for personal cleanliness, and while the meals were generally of good quality there was no variety of menu. No amusements were possible except occasional drinking and gambling, and added to these were the great difficulties in the way of a hired man starting in business for himself. Therefore, it became increasingly harder to obtain good teamsters for "eight-mule" teams at $1.50 and $2 per day, but tractioneers or "caterpillar skinners," as they are called in ranch parlance, could be obtained for $4 per day, and found.

A 75 or 80 b.-hp. tractor is supposed to do the work of four eight-mule teams, so an engineer at $4 and a plow tender at $2 would replace four teamsters at $1.50 each. The labor costs would therefore be alike for teams and tractor.

Fuel Costs

As far as fuel and oil costs are concerned on most ranches, it seems from the meagre figures available that it is immaterial whether you raise a certain amount of feed for the teams or whether you raise the same amount of grain and sell it to buy fuel and oil.

The first cost of the tractor and that of the four eight-mule teams were not far different, so the deciding feature was the ability to keep the outfit going. Had there been plenty of drivers the tractor would have been greatly delayed in getting a foothold, for it has been my experience that four *well-driven* eight-mule teams will out-plow the 75-hp. tractor in average plowing. The reason is that, in the case of the teams, there are four separate units and a temporary accident to one rig does not delay all of them, and, in addition, the rigs are more flexible and can get in and out of sharp corners better. In harvesting, the four teams are combined in one unit and have no such advantage over the tractor, but, on the other hand, the motion of the tractor is steadier, it makes turns quicker, and gets closer to ditches.

From this you may see that the essential thing for the operator is to keep going. The tractor, having been forced upon the rancher, is looked upon as a necessary evil and undeserving of sympathy, while the tractioneer is a man too lazy to drive a team and who is continually breaking into the bank account for salary and repair bills.

It must be further remembered that the tractor operator may be miles from a well-equipped machine shop and must rely on his collection of hand tools. His equipment for lifting consists of two 2-in. jack screws, whatever blocking there is lying around loose, and man power. Chain falls are rarely found on the ranches.

We will now take up some of the points of design that concern the operator in his task of "keeping her going" and will somewhat subdivide them.

The Motor

The carbureter has been advertised as the "heart of the motor," and likewise the motor may be considered the heart of the tractor. The tractor operator tries above all things to have a sweet-running engine; it is his source of power and it is vital that it shall run, and run well.

If time permits, the rest of the outfit is given some share of the attention, but the engine is first, last, and all the time the center of attention. One bugbear is that of heating, for, while the majority of automobiles are overcooled, the tractor is not. Here we have no letup of the load but a constant, steady drag. There is no chance to stop and let your engine cool off, nor to change the cooling water; therefore your radiator must be ample to care for the worst conditions possible.

It is not an uncommon thing to run when the thermometer registers from 90 to 120 deg. Fahr. in the shade and your tractor is in the sun. With the incoming air at 120 deg. Fahr. you have no great difference in temperature between the air and the water and must therefore rely on plenty of radiating surface and on the fan sending a steady volume of air through the radiator. The rate at which the water flows through the radiator tubes and the water jackets also greatly affects the cooling. A slipping fan or pump belt plays havoc with the cooling; therefore, these two should be run by extra wide belting or be positively connected to the engine.

The fan, if not belt-driven, should have a slip clutch to prevent blade damage. The pump must be located where it is under sufficient head on the suction side

to insure pumping even with very hot water. Also, most operators would appreciate a location where the pump may be packed without either standing on your head or else lying on your back under the machine and receiving the accumulated mud and grease from the frame and the hot water from the pump in your eye. Where the fan and the pump are belt-driven it might be well to remember that the belt pull may be considerable and that bearings should be ample and well lubricated.

Cooling is also made harder by the presence of scale-forming salts in the water which deposit in the water jackets and in the radiator spaces. At times the water must be taken from irrigation ditches and organic matter is introduced into the system, which blocks up the water passages, and therefore some means should be provided for cleaning these. The dust settling on the fins of the radiator tubes will cut down the transmission of heat through the tubes, and allowance should be made in the area allowed for cooling.

Care should be taken that the pump delivers water equally to all the cylinders, so some may not be heated while others run cool. Some companies use a tank in connection with the radiating system, and here it should be remembered that, while it is a nice thing to place it out of sight, there should be some way to remove it without taking off most of the decking and nearly all of the main drive shafting. The constant jar and bad water will make any tank leak in time.

Soldered Joints

Soldered joints in the radiator should be reduced to a minimum and allowance should be made for the expansion of the tubes. One western company uses packed joints with threaded glands, similar to those used in steam engine condenser practice, and from the operator's viewpoint it is an excellent system. The radiator should also be spring-mounted, to take off jars, which are considerably larger than most people imagine. A sight feed glass and a petcock should be located in the system so that the operator can tell whether the water is circulating properly.

The injection of water through the intake manifold has a tendency to keep the engine cool, but the proper regulation of the amount to be fed may give difficulty.

Another point that might be considered is that the heated air from the radiator, which is usually blown over the motor, is not very effective in cooling the cylinders. It might be better for the engine, and would be much better for the operator, if this were diverted from the motor. A blast of air at the outside temperature would help in keeping the cylinders cool.

Although it would add to the complication, some means of keeping the crankcase oil cooled would help wonderfully in keeping the motor temperature down.

A tractioneer hates to shut down a hot engine, because of the difficulty in starting it again. Sometimes a little oil poured in the air intake to the carbureter will aid greatly in cooling a hot engine, but care must be taken not to choke it with too much. The final method of cooling is to shut down and open up the crankcase and allow the air to circulate through the case freely. This is bad, owing to the dust that may be blown in. Starting the motor will be hard, due to the hot walls reducing the weight of charge entering the cylinders and also to the lubricating oil running down off the piston and the cylinder walls, thus making poor compression.

Aside from the foregoing considerations there is heating due to improper mixture, air leakage, etc., which are due to the engineer's negligence and must be charged up to the human element. The other extreme of overcooling in winter can be regulated by shutter control on the fan housing or by bypassing the water from the pump, either by thermostatic or manual control.

Next to heating, lubrication may be said to be the operator's worst trouble, although he is often unaware of the real cause. Most operators do not change their oil often enough, either because of lack of knowledge or of the owner's objection on the score of cost. The tractor manufacturer is largely to blame for this in not impressing on the owner the necessity for changing oil. The crankcase oil receives considerable carbon from deposits that form on the lower side of the piston head, due to the heat charring the oil, and which in time jar loose and fall into the oil pits. Dust also gets in during filling up with oil at night and in testing bearings. It is somewhat of a question as to whether a filler cap should be provided or whether a man should take off a side plate to put in oil. By taking off the side plate the bearings are more closely watched, and all tests for bearing looseness should be made on warm engine. In either case there should be no projecting ledges to catch dirt and allow it to fall into the oil when either the cap or door is removed. Of course, the operator should wipe this dust off, but when a man draws up alongside of a tank wagon just as the sun is going down, with an hour's work ahead of him in filling up and greasing, he is apt to let this slide.

A combination of splash and force feed lubrication seems to me to be the best solution of the lubrication problem. I doubt if the main bearings get all the oil they need with the constant level splash, while with a full force system failure of the pump would lead to speedy damage unless noticed by the operator. Either a gage or a sight feed glass should be provided, so that the operator may know whether the pump is working or not.

Crankcases

Crankcases which do not have sufficient drain plugs or have pockets that must be baled out and finally cleaned with rags or waste take up a needless lot of time in changing oil. As the oil pump periodically gets clogged with foreign substances, it would be well if it were so shaped and located as to be easily accessible. The oil pump should be at the lowest point in the system, so that the oil may get started immediately and so that the pump will deliver oil as long as there is any left.

Where overhead rockers are used with "valve-in-the-head" motors a cover should be provided to keep dirt from settling on the stems of the inlet valves and by its abrasive action soon cause trouble from air leakage into the inlet ports. Provision must be made for rocker-arm and valve-stem lubrication. If possible, this cover should be easily removable to allow turning the valves about a quarter turn each day to prevent uneven seating and thus making the valves run longer between grindings.

The governor working parts should by all means be dustproof and well lubricated. Also, the governor spring should be worked within a range of stresses where it will not be continually changing in value. A surging governor is extremely bad in pulling a ground driven harvester, which requires a steady gait to keep an even motion on the cylinder and fans. In exposed governors this surging is often caused by the gumming up of the moving parts with dirt and oil.

As many parts as possible should be oiled without the use of compression grease cups, to save time in filling up.

One make of tractor has over forty grease cups of various sizes. However, it should be remembered that there are places where the compression grease cup must be used, as a very effective way of keeping dirt out is to have plenty of grease on the inside of a bearing.

All gears should be enclosed and should be amply supplied with lubrication. Much grease is thrown off by exposed gears, and dirt collects in the grease that does stay on. Aside from the wearing of the gearing it is hard to keep your tractor clean with a grease-slinging device operating all the time, and a dirty tractor is the beginning of trouble.

Some of the tractor makers are fitting dust strainers on the intake air to the carbureter, and all of them should. Most people do not realize the amount of dirt that gets into the cylinders through the carbureter.

Control

A simple hydraulic clutch and speed control or a correspondingly simple magnetic control would be a welcome thing for the tractor operator. At present a man is between the two fires of starting with a jerk or burning out the clutch by slipping. In crossing ridges and ditches the clutch must be released to prevent the front end from rising and dropping suddenly. All of this causes wear on the lining. A more liberal design would be better than the present, and most tractors are designed for too great a pull on the levers. Exercising a pull at frequent intervals and only once or twice an hour are entirely different propositions.

Another fault is that there is too much spring in the levers. Rim or band clutches in which two opposing toggles must be equally adjusted for correct action should have some equalizing device independent of the clutch adjustment. Since clutches in the neighborhood of gears are apt to be covered with oil, in spite of the operator, they should be designed to carry the load on the assumption that they are to run in oil.

Steering should be made as easy as possible and power steering gear should be fitted to the larger tractors, especially if there is much weight on the front end. However, it is possible to steer 75-hp. tractors by hand without excessive exertion if the steering gear is built correctly.

Tracks

Means must be provided to allow the operator to keep his sprockets and tracks in correct alignment. A round-head track bolt, even if fitted with a square shoulder fitting in the track shoe, is mean to handle, as it is only a short time until the shoulder wears enough to turn. Either a solid link and shoe or some means of bolting on so that the bolts will stay tight must be developed, especially for road work.

Starting

For the average tractor operator, starting either by bar or by turning the flywheel by hand is not a serious thing under ordinary circumstances. However, it is not an easy thing for a light-weight man, and on a cold morning or with a hot motor it is hard work for the best of them.

As there is no housing of the tractor at night, everything is thoroughly cold on the tractor in the morning. The oil is thick and the motor turns over hard, while the gasoline and distillate are in poor shape for vaporizing. Engineers use various methods for starting on cold mornings, some of them dangerous.

1—Prime each cylinder with *gasoline*, either through priming cocks or through spark plug holes. Turn engine over several times with ignition off and allow to stand a while. This allows some of the gasoline to vaporize and diffuse through the mixture. Then prime engine again through priming cock and turn over with ignition on. Under ordinary conditions the engine will start the first time, but on cold mornings more severe methods must be used.

2—Put the gasoline priming can in hot water. I have seen engineers put the can in a fire or hold it over a blowtorch until the vapor begins to distill off. Prime with this warm gasoline.

3—Warm up intake manifold and inside of cylinders through spark-plug holes with blowtorch; but care must be taken to stand clear of any possible flame from cylinders. Heat spark plugs.

4—Pour gasoline or distillate over the heads and manifolds and set fire to it. Care must be taken that there are no pipe line or tank leaks near the flame.

5—Prime with a mixture of gasoline and ether. Too much ether will lift the heads.

6—Above all do not prime too much, as the raw gasoline will wash the oil away from the rings and spoil the compression. Sometimes priming with a mixture of oil and gasoline or a little oil alone helps greatly.

The fact that these severe and more or less dangerous methods are in common use shows the necessity for some good starting system combined with a method of getting an explosive mixture into the cylinder independent of the regular carbureter.

Fire Hazards

Although many fires were started before tractors were used and many are blamed on tractors where something else is responsible, the fact remains that a tractor in a grain field, dry as tinder, is a source of danger. Fires may be started by pieces of carbon thrown out of the exhaust, by pieces of hot wire blown off the spark arrester, by chaff or straw falling on the hot exhaust manifold and dropping off into the stubble, or by a pop back in the carbureter in starting, and especially if the operator squirts gasoline into the air intake, as most of them do.

Some owners place a 30-gal. stove boiler, with the top head removed, on the front end of the tractor and bring the exhaust pipe of the engine down into the tank, so the exhaust gases must make a 180 deg. turn to get out. The lower portion of the tank up to about 6 or 8 in. of the end of the exhaust pipe is filled with water which quenches the hot particles of carbon, which are too heavy to turn with the gases. This tank, while very effective in catching carbon, increases the back pressure on the engine and thus adds to the heating troubles.

In addition a fire extinguisher is carried on the engine and one on the harvester. A can of water filled with wet sacks is also carried on the tractor, and on windy days a man follows the outfit on a saddle horse to watch for fires. For quick action he carries a wet sack on the saddle strings. On very windy days the outfit stops.

General Operation

A gas tractor is excessively cold in winter and very hot to work on in summer. In the colder climates provision should be made for a cab, but care must be taken to keep out exhaust gas from this cab. If the hot air from the fan were not driven back on the operator it would be cooler in summer.

A clear view ahead of the tractor should be provided, as it helps wonderfully in coming up to ditches and corners.

Clutch brakes should be provided to keep the master clutch from spinning if the gears happen to be in the neutral position.

(*Continued on page* 1359)

Matthews Full Automatic Lighting Plants

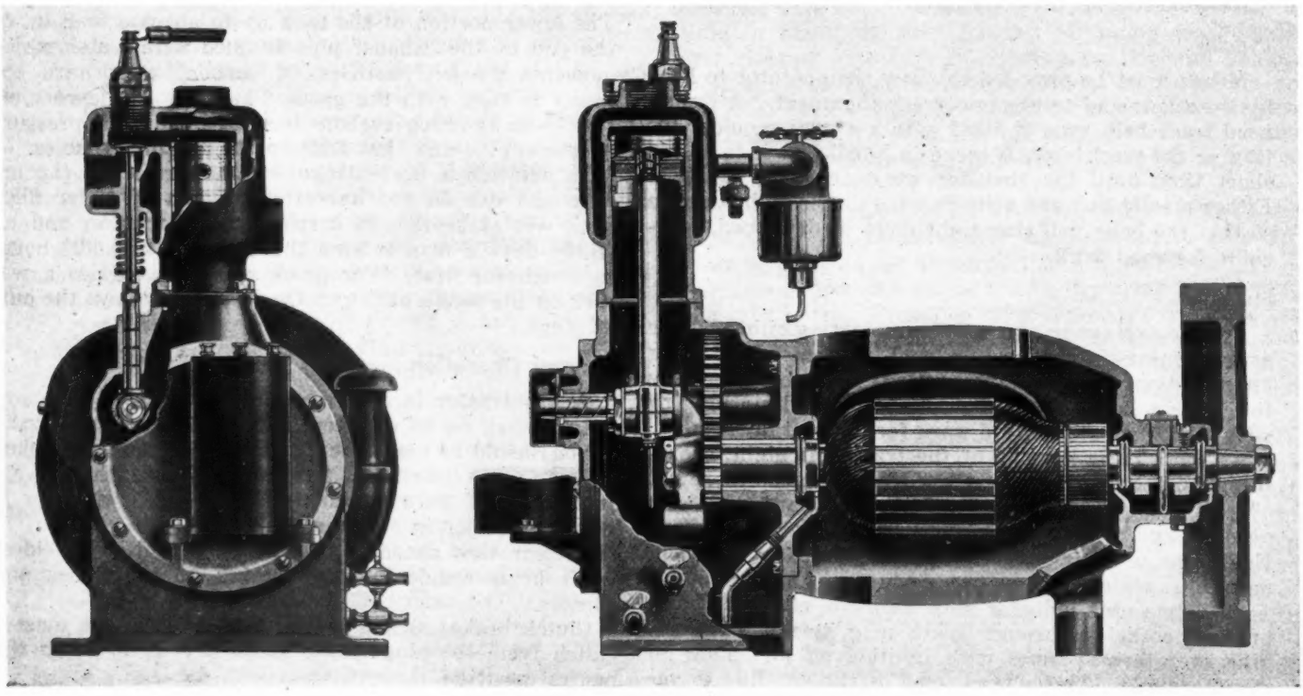
Made in Capacities Ranging from 300 Watts to 6 Kilowatts—Start and Stop Automatically, as Required by State of Battery Charge or the Amount of Load on the Line — Plain Generator Set Also Furnished

By P. M. Heldt

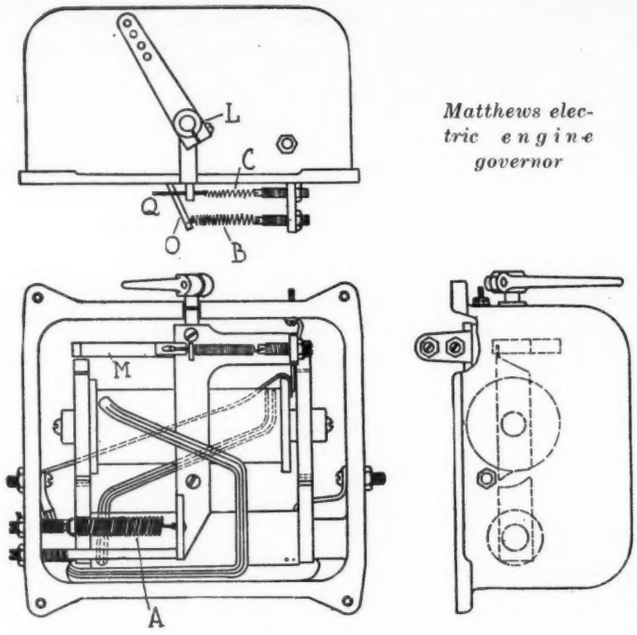
THE Matthews Engineering Co. of Sandusky, O., manufactures electric lighting plants in sizes ranging from 0.3 K. W. to 15 K. W. The line comprises automatic plants in 0.3, 1, 2, and 6 K. W. sizes and non-automatic plants of 1, 5, 10 and 15 K. W. In addition to these, a 12 K. W. plant is made, which comprises two 6 K. W. automatic generators connected in parallel. The smaller plants are used largely for lighting farms and private country houses, while the larger units find application in lighting and furnishing motor power for large estates, ranches, stores, dairies, churches, small towns, moving picture theatres, etc. It will be be noted that the automatic feature is used mainly in connection with the smaller plants. The reason for this is that with large plants there is usually some one who is looking after the installation all the time, and automatic control is not then essential.

All of the automatic plants are, naturally, very much alike in design, so far as their electrical features are concerned. We have selected the 1 K. W. and the 300 watt plants for description. The former comprises a single cylinder, water cooled, upright engine, having cylinder dimensions of 3 x 3 in. The cylinder is of the "L" head type, with integral cylinder heads, the crankcase being cast separately. There is a large hand hole with cover plate on the side of the crankcase through which access can be obtained to the crankshaft and connecting rod bearings. The plant is of the 3 bearing type, that is, there are two bearings in the engine and one in the generator. The engine bearings are made of S. A. E. specification babbitt, and are extra large. The armature shaft is piloted in the end of the engine crankshaft, and is driven from the latter through a sort of jaw coupling. The crankcase is cast with two large openings on the end, over which are bolted the bearing plates. In order to insure absolute alignment of the engine bearings, these are line-reamed. The generator is held in alignment with the engine by means of a connector flange to which the former is bolted.

Owing to restrictions on the amount of gasoline which can be kept within a building, the gasoline tank



Sectional views of 300-watt generator



Matthews electric engine governor

from which the fuel is drawn is located outside the building, and a 5 ft. length of copper tubing is furnished with the plant, by means of which connection can be made from the storage tank to a Stewart vacuum tank, which is secured to the cooling tank. The latter is an electrically welded steel barrel, 19 in. in diameter by 34 in. in height. A Schebler Type B carbureter is fitted, which is controlled by an electric governor. This governor has both a shunt and a series winding. It is so designed that when the generator is carrying only battery load, the generator voltage is maintained to give the proper charging rate; that when there is a lighting load in addition to the battery load, the throttle will be opened wider and more current will be generated to take care of this additional load. Battery charging is continued until the charge is complete, when the plant will be automatically shut down.

The governor consists of an electro-magnet with rotating or rocking armature to the shaft of which the governor lever is connected. The governor has both a shunt and a series winding, each winding being on a separate spool. There are three adjusting springs on which adjustments are made under the following conditions: If the governor fails to open the throttle sufficiently as the load is thrown on, and in consequence the battery begins to discharge, spring A should be slightly weakened: if when the plant is started the armature M does not assume its normal running position, that is, if the lever O does not come up against the far end of clip Q, then the adjusting spring B should be weakened; if, under normal running conditions with the battery connected to the plant, clip Q should not be up against the stop, then the adjusting spring C is too weak and should be strengthened. It will be noted that the governor lever is provided with a number of holes so that its effective length can be varied, and the lever can also be adjusted on its shaft by means of the clamp screw at the hub.

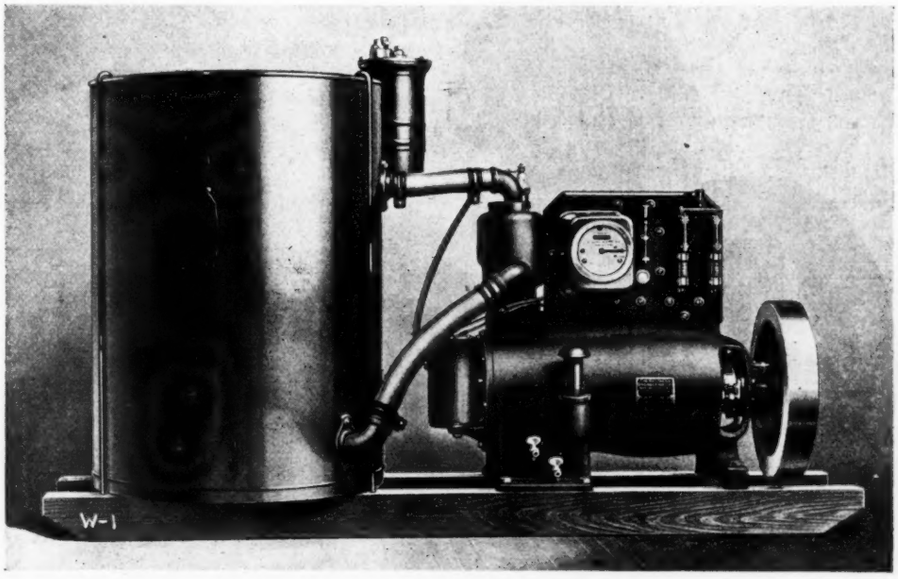
Ignition is by a 32-volt vibrating coil in conjunction with a timer. The spark plug is screwed into the valve cap. Lubrication of the engine is by splash. A large crankcase oil reservoir is provided and there are hand holes in the crankcase on both sides. Four feet are cast on the crank chamber by means of which the engine is supported upon a channel iron frame.

Ordinarily, starting is effected electrically, but for emergency cases a starting crank is provided, the shaft of which passes underneath the cooling tank to the end of the supporting frame. Cooling water is circulated by thermo-siphon action, the connections between the jacket and tank being of ample dimensions.

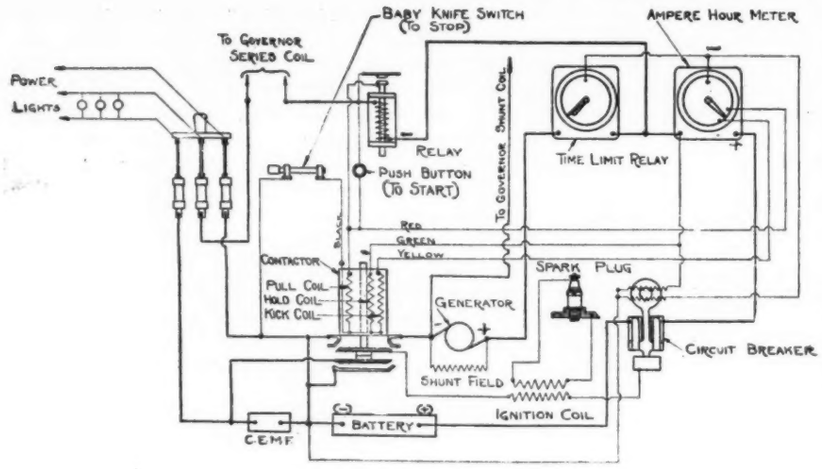
The generator is of General Electric make, and is a 4 pole type with laminated fields. Wave armature winding is used, and there are four brushes on the commutator. The outer end plate of the generator is cast with feet which rest on a cross member of the frame. The generator is wound for 32 volts, supplying current to a 16-cell Willard battery.

The battery consists of 16 cells and 1 counter-cell, and has a capacity of 72 ampere-hours. The generator set occupies 60 x 21 in. floor space, is 42 in. high and weighs complete 480 lb., while the battery occupies 39 x 18 in. floor space, is 21½ in. high and weighs 271 lb.

The 300 watt outfit is probably the smallest commercial electric lighting plant ever manufactured, and its design has been reduced to the simplest form. Thus, the generator field frame and the engine crankcase are a single casting; likewise, the engine crankshaft and the armature shaft are one and the same piece. The set comprises a single cylinder, vertical, water cooled engine of 2 in. bore by 3 in. stroke, with integral cylinder head. An overhanging crankshaft is used, which is hardened and ground, and held on by taper, key and nut. The plant is a two bearing job, having one bearing between generator and engine, and one generator outboard bearing. Non-Gran bronze bearings are used with a ring oiler on the generator bearing. The connecting rod is made of bronze with



Three-hundred-watt plant complete



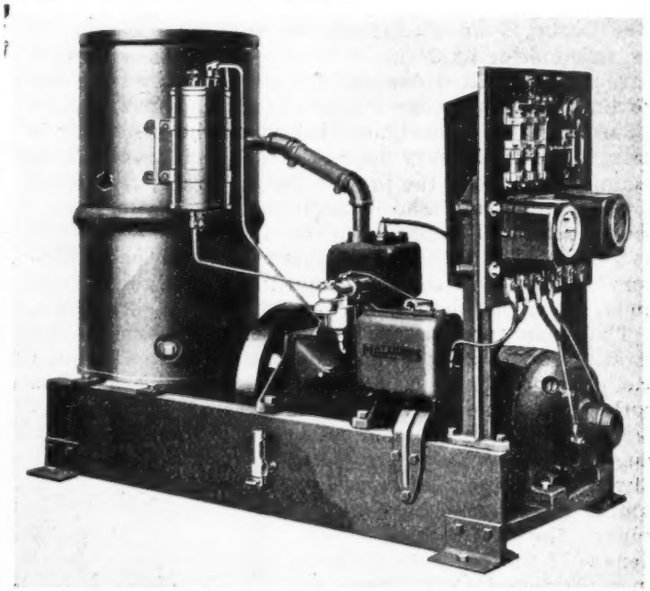
Circuit diagram 1 K. W. set

adjustable bearing, and has an oil thrower secured to it. The crank is counterbalanced so as to insure smooth running. On the cam-shaft bearing there is a spiral groove which has a tendency to pull the oil in and keep the engine clean. Spur gears are used for the cam-shaft drive, the large gear being made of cast iron, and the pinion of steel. A mushroom type cam follower is used, and an adjustable tappet. The clear diameter of the valves is 15/16 in. The valves have cast iron heads and steel stems. The piston has 3 rings and is fitted with a tubular piston pin which is hardened and ground.

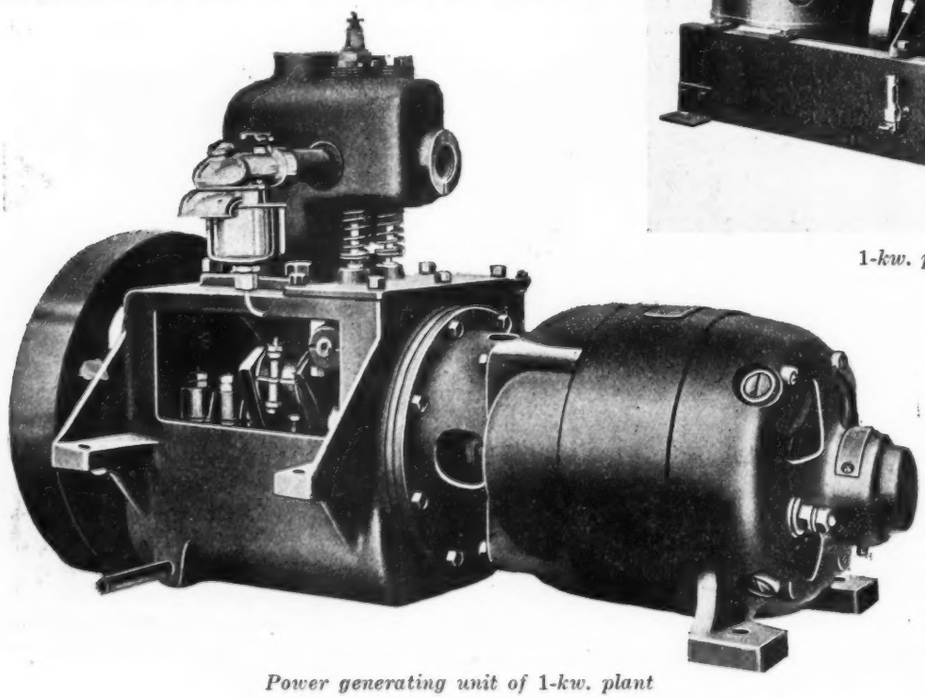
A Stewart vacuum feed system is supplied and thermo-siphon circulation of cooling water is used. The cooling tank measures 16 in. in diameter by 24 in. in height. The carbureter is the Schebler model B, and is provided with a throttle lock device so the generator output cannot exceed 300 watts. Otherwise, if the engine were run under full throttle, it would be possible to get an output of 425 watts.

Ignition is by a 32 volt, single spark, non-vibrating coil, the interrupter being mounted on the end of the camshaft. The flywheel is held on by a taper and key. Oiling is by splash. There is a check valve in the oil return pipe from the main bearing so that the crankcase compression cannot force oil up this pipe and cause excess lubrication. A vacuum type of breather is used, that is, a breather with a valve which opens when there is an excess of pressure in the crankcase and closes when there is a partial vacuum.

The generator is of the two pole shunt-wound type, and has an extra large armature shaft. The field frame and the engine crankcase being one casting the boring of the armature tunnel and of the two main bearings can be effected in one setting. There are two main brushes on the commutator which are in the regular position, 180 deg. apart, and in addition there is a third brush slightly behind one of the main brushes. A voltage of 36 is obtained between the main brushes, and these are connected across the storage battery, while a voltage of 32 is obtained between one main brush and the auxiliary brush, and the lighting load is connected between these two brushes. The flywheel is located outside the generator and has a weight of 22 lb. There is no flicker of the light with the engine running at 1250 r.p.m.



1-kw. plant complete



Power generating unit of 1-kw. plant

The switchboard and instruments are much the same as on the other system. Lugs are cast on the field frame for holding the switchboard. The ignition coil is mounted on the end of the engine crankcase and is therefore close to the interrupter and the spark plug.

In the foregoing description the term "automatic" has been used repeatedly, and it may be well to explain exactly what this term covers as applied to this plant. In the

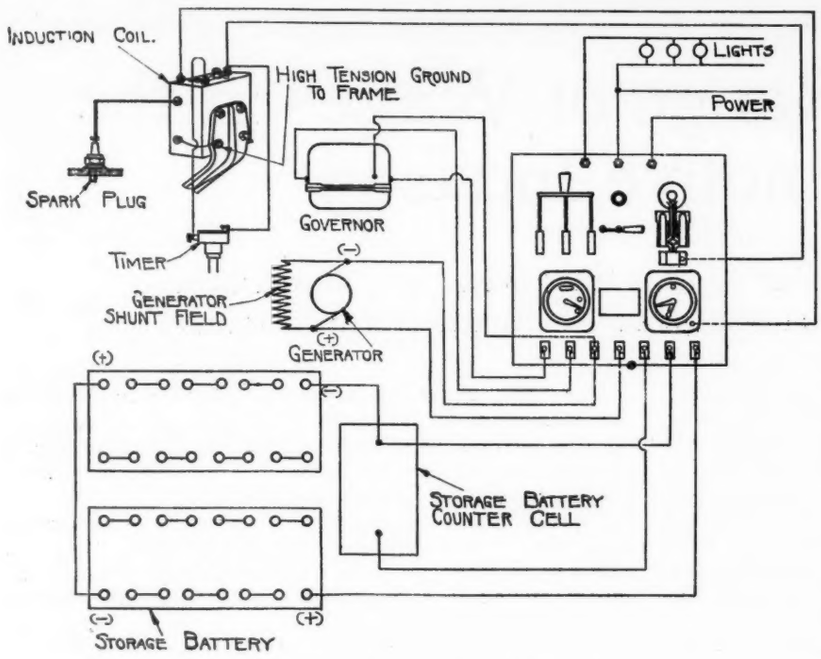


Diagram of connections 1-kw. set

first place, as soon as approximately 15 per cent of the battery charge has been withdrawn, the engine will start automatically and begin to recharge. If only a few lights, say 10 or 12, are turned on they will be supplied with current directly from the battery and the plant will be idle until 15 per cent is taken from the battery. If a larger number of lights are turned on, say from 15 to 20, the generator will recharge the battery in the usual way, but when a state of full charge is reached it will not stop unless some of the lights are turned off. If an electric motor is switched on to the circuit the engine will immediately be started, and the entire load will be carried by the generator, irrespective of the state of charge of the battery. Once started, the engine will not stop until the batteries are completely charged, and as the generator carries all the heavier loads, even if the batteries are entirely full, a slow overcharge is obtained which keeps the battery in good condition.

The automatic features of the Matthews lighting system are based on the Sangamo ampere-hour meter and an overload relay. All current passing into and out of the battery flows through this meter and causes the indicator hand of the instrument to turn on its dial. The complete discharge would move the indicator hand about one-third around the dial. Contact points are secured to the dial plate in the positions corresponding to an empty battery, to a full charge, and to an 85 per cent charge. When the battery is being charged, the hand of the meter turns in a clockwise direction.

On discharge as soon as the meter hand reaches the "start" point the engine is started and begins to charge. Of course, not as much current can be taken out of a battery as has to be put into it during the charge, and in order to make up for the difference, the ampere-hour meter is so designed that its hand moves from 20 to 25 per cent slower on charge than on discharge, for a given rate of current flow. As already explained, if there is only a very small lighting load on the circuit when the battery is fully charged, the plant will be shut down. However, if a lighting load on the circuit is 17 amperes or over the plant will continue to run, and in consequence some additional current will flow into the battery. When the charging operation is over, the meter hand is always at "full," corresponding to the condition of the battery. It takes approximately one hour to charge the battery from the time the engine is started until the meter hand reaches the "full" stop.

There is another condition which must be provided for in a mechanism of this kind, in order that the charge of the battery may always be maintained. It is well known that when a battery is standing idle for a considerable period there is always a slow leakage of current. This leakage current, of course, does not flow through the ampere-hour meter, which consequently does not show the discharge of the battery. To take account of this discharge by leakage, the ampere-hour meter is provided with a thermocouple, which causes the disc of the meter to slowly revolve in the discharge direction, so that every 4 or 5 days the plant will automatically start and recharge the battery, even though no lights are ever turned on and no current is consumed.

One of the illustrations herewith shows a complete wiring diagram of the plant, in which are indicated not only the connections between the generator, battery and load, but also the connections of the ignition system and the electric governor. All of the instruments are mounted on a switchboard which has an elonite asbestos base. These instruments include a contactor, an overload relay and a circuit breaker. the ampere-hour meter and a device of the same class known as a time limit relay. The contactor is in the form of a solenoid switch with three coils. One of these is referred to as a pull coil, the second as a hold coil, and the third as a kick coil. The engine can be started in several different ways, one way being by means of a push button on the switchboard. Normally, the engine is started by the ampere-hour meter. When the hand of this meter comes around to the starting contact the circuit is closed through the pull coil of the contactor, and the battery is thereby thrown into circuit with the generator, starting the latter as a motor. The ignition circuit of the engine is also closed through the starting contactor, so that the "spark" is on the moment the engine begins to turn over.

As above pointed out, when sufficient current is being used in the consuming circuit the engine will start, irrespective of the position of the hand on the ampere-hour meter. This is effected by a device called an overload relay—an electro-magnetic switch through which flows all of the current supplied by the plant. When the plunger of the relay is strong enough it pulls it up, thereby closing the circuit through the pull coil of the contactor, which starts the engine.

In addition to the apparatus described above, the switchboard contains a time limit relay, the function of which is to open the battery circuit in case the engine for any reason should fail to pick up its cycle while it is being cranked by the generator. This would happen, for instance, if there was no fuel in the tank. When the battery is discharging the hand of the time limit relay turns clockwise, and vice versa. However, when the battery is being charged the hand can only

(*Continued on page* 1359)

Four-Year Range of Wages in the Automotive Industry

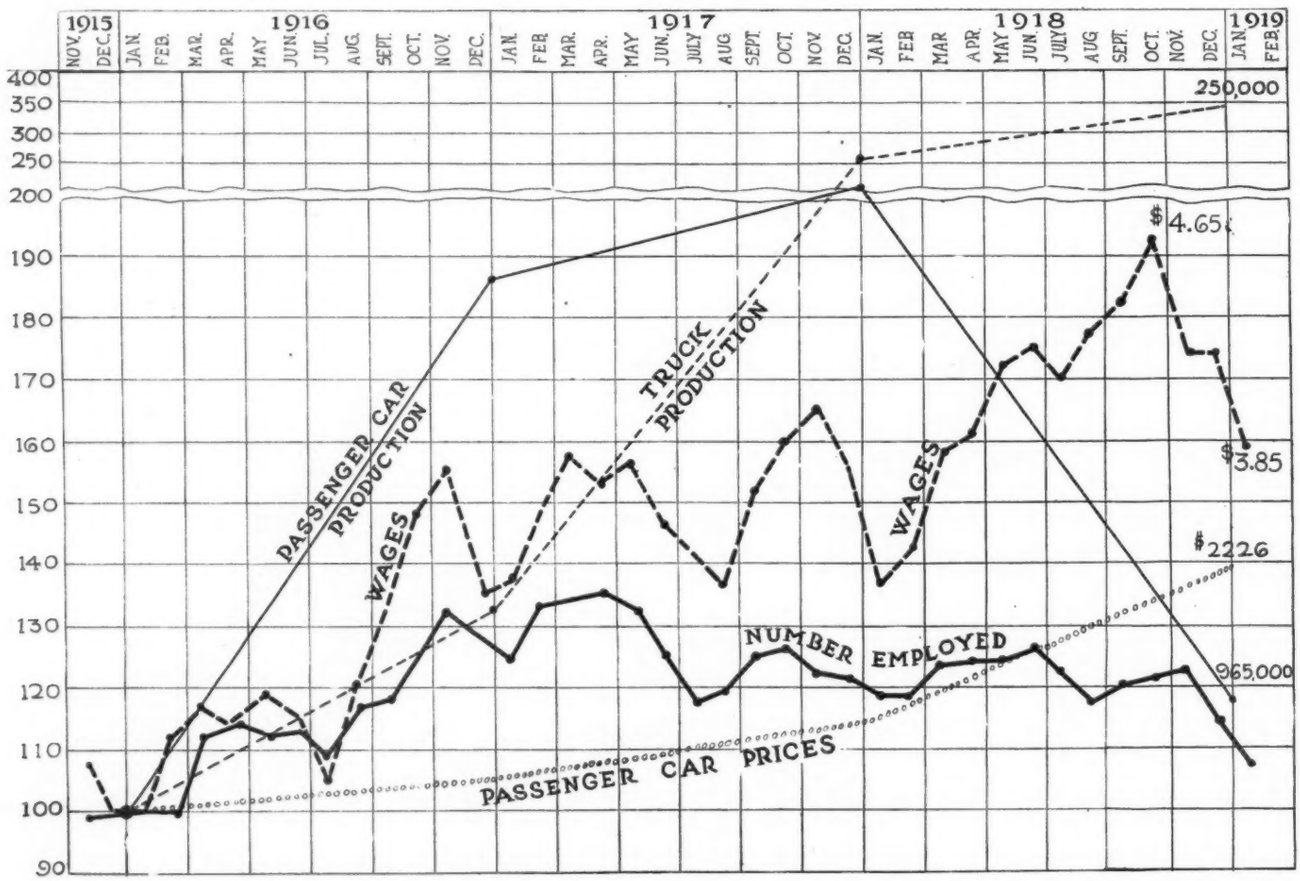
Influence of the War Upsets the Basis of Comparisons Previously Employed—Seasonal Fluctuations Still Obtained

WASHINGTON, June 7.—Wages in the automobile industry were increased from $2.50 a day average in 1915 to $4.65 a day average in 1918. These figures are obtained from reports made to the Department of Labor monthly by automobile manufacturers. The number of companies reporting range from 36 to 52.

The accompanying charts were compiled from these reports and present the wages, numbers employed, production and selling prices in the automobile industry, the average daily wage and the average daily number employed, the prices of basic commodities, and the wages and number employed in other similar industries.

The tables show the wages and number employed in the automobile industry only. For the sake of comparison, where months of different years are used to obtain percentages, reports from the same factories only were used, regardless of the number filed.

In accounting for increase of wages in the industry many factors must be taken into consideration. The first cause undoubtedly was the effort to meet the demand for quick production of war materials for our allies, much of which was made in automobile factories. After the declaration of war by this country, the withdrawal of men for military purposes became a serious factor. The



PASSENGER CAR PRODUCTION--100 = 818,000
PASSENGER CAR PRICES-------100 = $1,600
TRUCK PRODUCTION----------100 = 74,000
WAGES----------100 = $2.42

Chart 1—Showing the number employed, daily wage in the automobile industry and production and average selling prices of passenger cars and trucks

Wages and Numbers Employed in Automobile Industry

Mo.	Establishments reporting	Number on weekly payroll in 1916	Number on weekly payroll in 1917*	Per cent of increase or decrease	Amount of weekly pay roll in 1916	Amount of weekly pay roll in 1917*	Per cent of increase or decrease	Daily average number employed per factory 1916	Daily average number employed per factory 1917	Average daily wage 1916	Average daily wage 1917*
July	36	90,942	92,354	1.6	$1,615,257	$2,154,737	33.4	2526	2565	$2.54	$3.55
Aug.	42	104,001	107,024	2.9	2,028,049	2,305,983	13.7	2476	2548	3.08	3.61
Sept.	38	89,926	91,742	2.0	1,861,768	2,158,537	15.9	2366	2414	3.45	3.92
Oct.	43	115,549	110,427	—4.4	2,409,981	2,610,926	8.3	2687	2568	3.49	3.60
Nov	40	107,479	101,365	—5.7	2,375,177	2,529,603	6.5	2686	2534	3.84	4.16
Dec.	47	104,638	101,415	—3.1	2,165,965	2,496,948	15.3	2226	2153	3.45	4.10
		1917	1918		1917	1918		1917	1918		
Jan.	45	110,256	98,816	—10.4	2,183,095	2,122,457	—2.8	2450	2190	3.28	3.58
Feb.	48	134,387	119,882	—10.8	2,840,688	2,668,866	—6.0	2799	2497	3.52	4.08
March	50	137,093	125,277	—8.6	3,073,893	2,981,051	—3.0	2741	2505	3.73	3.96
April	50	125,407	117,352	—6.4	2,761,526	2,846,438	3.1	2508	2347	3.67	3.87
May	47	120,112	114,745	—4.5	2,773,654	3,011,044	8.6	2555	2441	3.85	4.37
June	47	104,024	109,669	5.4	2,337,951	2,858,794	22.3	2213	2333	3.74	4.34
July	48	127,962	128,473	0.4	2,810,608	3,243,692	15.4	2665	2676	3.51	4.13
Aug.	46	118,477	119,004	0.4	2,553,961	3,208,572	25.6	2575	2587	3.59	4.50
Sept.	48	113,889	117,290	3.0	2,614,888	3,215,836	23.0	2372	2443	3.84	4.57
Oct.	52	136,589	135,313	—0.9	3,241,109	3,776,737	16.5	2626	2602	3.95	4.65
Nov.	51	79,831	87,536	9.7	1,721,481	2,155,906	25.2	1565	1718	3.59	4.08
Dec.	48	108,498	114,427	5.5	2,608,839	3,058,385	17.2	2261	2383	4.00	4.45
		1918	1919		1918	1919		1918	1919	1918	1919
Jan.	49	106,993	112 984	5.6	2,277,082	2,979,959	30.9	2181	2305	3.56	4.39
Feb.	47	109,583	110,472	0.8	2,445,176	3,240,057	32.5	2331	2350	3.72	4.96

*Where monthly figures are used for the sake of comparison with the previous year they are reduced to the same basis as the reports of the previous year. Viz., the report of the number employed in July, 1917, when used for comparison with 1916, is that reported by the same 36 factories as reported in 1916.

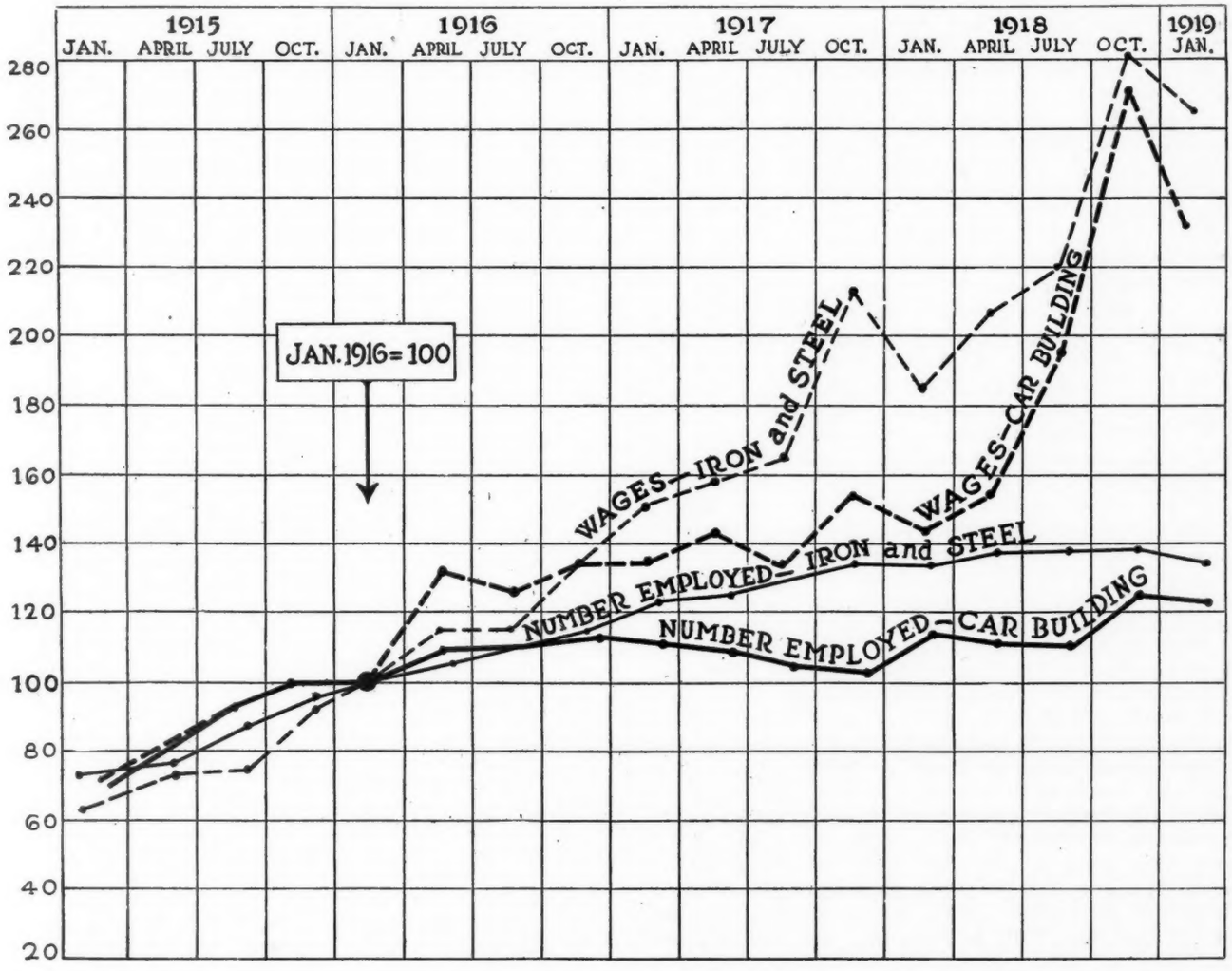


Chart 2—Relative number employed and wages paid in other large industries, based on figures for January, 1916, as 100 per cent

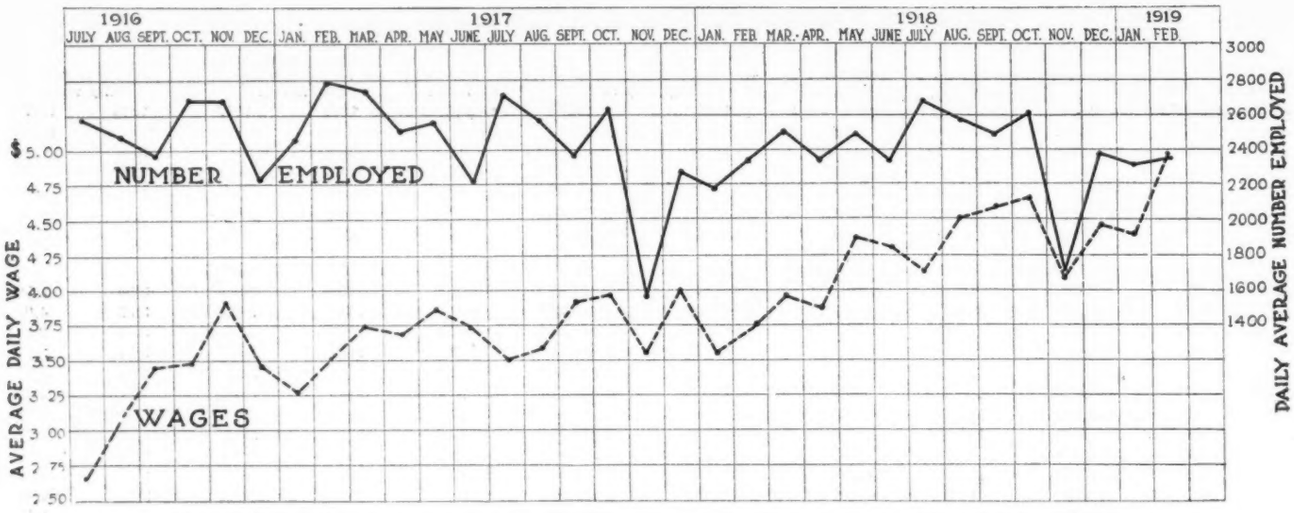


Chart 3—Showing the average daily number employed and wages in the automobile industry

high cost of living later became a contributory factor, but usually the demand for men in the automobile factories kept the wage increase in the industry ahead of the cost of living increase.

There is a close relation between the numbers employed in the automobile industry and in the kindred iron and steel and car building industries, as shown in Chart 2. In all of these industries the wage scale increased considerably more than the number employed, which usually is an indication of the wage increase.

Increased prices for passenger cars have apparently had no serious effect upon the sales, as production increased constantly and in even greater degree than the selling prices up to 1918 when government control limited the output.

Seasons Maintained

That the numbers employed and the wage scales rise and fall simultaneously in normal times is indicated by the curves from November, 1915, until November, 1917, following which time the effect of the war became noticeable and the wage scale of the automobile industry increased while the numbers employed decreased (see Chart 1). Shortly after, in January, 1918, the influence of the war on production and working organizations was marked with a decline.

Prices of steel and iron rose to unprecedented heights in 1917, increasing more than 300 per cent. A reduction to an increase of 150 per cent above pre-war prices was effected in 1918 when the government exercised its price control. Crude rubber, although fluctuating during the past four years, has maintained a fairly stable price level.

It is particularly interesting to note (Chart 3) that the wages from July, 1916, to February, 1918, rise and fall in practically the same months as the wages from July, 1917, to February, 1919, although the latter scale is approximately 50 per cent higher, indicating that some such influences as inventory or selling seasons or production seasons have a slight effect. Similarly the size of the working organizations rises and falls in similar months for different years. Apparently the war had very little influence on those factors which caused the slight increases and decreases that mark the different months on the chart as it will be noted, the number employed from July, 1916, to February, 1918, had decreases in December, 1916; June, 1917, and November, 1917, which were again displayed in the curve for the period July, 1917, to February, 1919.

The increased price of passenger cars is apparently due equally to the increased prices of steel and iron and the growing wage scale.

In the table showing the wages and numbers employed in the automobile industry it will be noted that wage increases have been as high as 33.4 per cent for one year while decreases have never totaled more than 6 per cent. Working organizations have increased as much as 9.7 per cent when in November, 1918, they increased to 87,536 from 79,831 employed in the same month of the preceding year. The greatest wage increase was recorded in July, 1917, when the pay roll of thirty-six manufacturers totaled $2,154,737 as compared with $1,615,257 in the same factories for July, 1916. A considerable increase was also noted in February, 1919, when the pay roll totaled $3,240,057 as compared with $2,445,176 for February, 1918, an increase of 32.5 per cent.

Relative Wage and Number Employed in Automobile Factories

FROM NOVEMBER, 1915, TO JANUARY, 1919, IN WHICH JANUARY, 1916, EQUALS 100 PER CENT

Month and Year	Number on Pay Roll	Amount of Pay Roll
1915—November	99	108
December	100	100
1916—January	100	100
February	112	111
March	114	117
April	112	114
May	113	119
June	109	115
July	116	105
August	117	119
September	123	132
October	132	148
November	129	155
December	125	135
1917—January	133	137
February	134	149
March	135	158
April	133	153
May	130	156
June	125	146
July	118	141
August	120	136
September	125	153
October	126	160
November	122	165
December	121	156
1918—January	119	137
February	119	142
March	123	158
April	124	161
May	124	172
June	126	175
July	122	170
August	118	177
September	120	182
October	121	192
November	123	174
December	114	174
1919—January	108	159

A Review of the Motor-Fuel Situation

Limitations and Possibilities of Different Fuel Sources — Interrelations of Engine and Fuel Development — Comments on the Essentials of a Research Organization

By Joseph E. Pogue*

THE rapid growth of the automotive industry has so increased the demand for motor-fuel that the ability of the fuel supply to keep pace has come into question. As a stringency in fuel supply will prove a retarding factor in the expansion of the automotive industry, the subject is a vital one not only to automotive manufacturers, but to the general public as well. A review of the motor-fuel situation as it stands in 1919 is, therefore, timely, for only by widespread appreciation of the nature of the fuel problem and especially of the steps that may be taken in solution can the most favorable outcome be assured.

THE PETROLEUM SITUATION

Crude petroleum to the extent of approximately a third of a billion barrels is mined annually in the United States. Most of this quantity is refined to produce gasoline, kerosene, fuel oil, lubricating oil, and various by-products. The relative production of these products in 1918 is shown in Fig. 1.

Gasoline, of course, is the predominant motor-fuel in use in this country; kerosene is coming into prominence as a motor-fuel, although a small part only of the output as yet finds such application; fuel oil, which bulks larger than gasoline and kerosene combined, is mostly employed for firing boilers, although a trifling quantity is used in Diesel engines and a small fraction is converted into gasoline through processes of pressure distillation known as "cracking."

The Joint-Product Character of Gasoline.—Gasoline is not an independent product, free to respond singly to motor-fuel demands, but is intimately tied up with the production of other constituents of crude petroleum, especially kerosene and fuel oil. In consequence, the price and supply of gasoline are influenced by market conditions holding for kerosene and fuel oil.

Before the vogue of the internal combustion engine, gasoline was a by-product of little value turned out in connection with the manufacture of kerosene, but the rapid upgrowth of the light motor has brought gasoline into more urgent demand than either kerosene or fuel oil, with a resultant price discrepancy between the three (see Fig. 2). Means, however, are now developing for converting kerosene and fuel oil into gasoline, as well as for using them directly in motors, and in proportion as the motor-fuel demand encroaches upon these cheaper products their price advantages over gasoline will tend to disappear.

The close interplay between gasoline, kerosene, and fuel oil, arising from their production in common from a single raw material and their (as yet limited) interchangeability, is a factor of great significance which should be held clearly in mind in viewing the motor-fuel situation.

Era of Surplus Gasoline.—Until recently, crude petroleum was mined in gross excess of the quantity necessary to provide an ample supply of gasoline. Much gasoline in consequence was unrecovered from the crude petroleum brought into use. This gasoline represented "slack" in the situation (see Fig. 3). During this period, expansion in gasoline output was readily effected merely by subjecting a growing share of the crude output to refining.

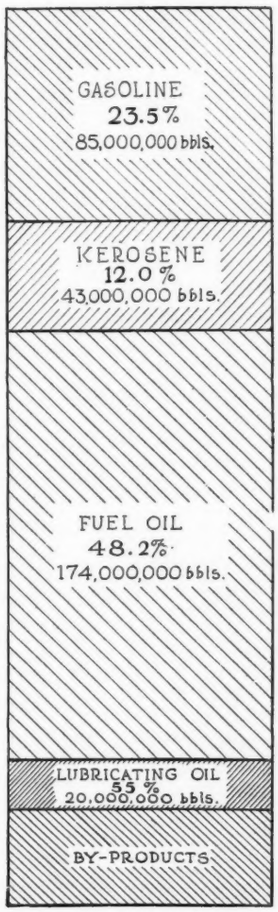


Fig. 1 — The production of petroleum products in the United States during 1918

Even though the rate of increase in gasoline production has for some ten years exceeded the rate of increase in production of crude petroleum, no stress was felt until the gasoline "slack" began to run out around 1917. Then the burden shifted to more rigorous means for sustaining the supply.

The Era of Tightening Gasoline Supply.—At present practically all the easy-to-extract gasoline is removed from the crude petroleum mined, and the motor-fuel demand is not filled by the quantity obtained. A growing discrepancy is covered by cracking fuel oil into gasoline, by lowering the volatility of gasoline which permits a larger percentage (at the expense of kerosene) to be extracted, and by gathering the gasoline suspended in natural gas. These economic expedients are recent developments, and are being called more and more into play by the rapidly expanding demand for gasoline. In the absence of conspicuous gasoline "slack" within the crude supply, the expansion in output of crude petroleum has ceased to be adequate to accommodate the situation.

Supply of Crude Petroleum Limited.—Not only is the production of crude petroleum failing to keep pace with the demand for motor-fuel, thus already forcing into play other expedients for expanding the supply, but also the unmined supply of petroleum has a physical limit which is rap-

*Division of Mineral Technology, U. S. National Museum. Formerly of the Oil Division, U. S. Fuel Administration.

idly being approached. The U. S. Geological Survey in early 1919 estimated, on the basis of extensive engineering data, that the available petroleum still underground in the United States approximates 7,000,000,000 barrels.

In view of the large and rapidly increasing annual draft upon this reserve, the supply seems startlingly inadequate to sustain the motor-fuel situation for any satisfactory period of time. Moreover, it is well known, because of the greater extent of drilling necessary, that petroleum may be mined only at increasing cost and with increasing difficulty as the resource is depleted. It is already a common belief among petroleum engineers that the oil output of the United States has practically reached its maximum.

The recent interest on the part of the oil industry in acquiring reserves of petroleum in Mexico and South America is but the business reflex to this point of view. But even with the most optimistic assumptions on behalf of contributions from foreign countries, it can scarcely be hoped that the petroleum reserve available to the automotive industry of this country will be found to exceed twice the quantity now in sight.

Supplementary Gasoline from Natural Gas.—At present a highly volatile gasoline is extracted from natural gas in many parts of the country and blended with petroleum distillates too heavy alone to be marketed as gasoline. In this way, commercial gasoline in quantity aggregating about 10 per cent of the total supply is manufactured. The production cost of such gasoline is low and the growth of this industry has been rapid in the past few years. The contribution of this by-product source, however, is limited as to the future, since natural gas is a waning industry and gasoline is already being extracted from roughly half of the supply.

Cracked Gasoline from Fuel Oil.—Fuel oil, the petroleum product turned out in greatest bulk and selling around a quarter to a fifth the price of gasoline (see Fig. 2), is the source of a growing quantity of gasoline. By special methods of distillation, certain qualities of fuel oil are transformed or "cracked" into a grade of gasoline that is mixed with straight refinery gasoline

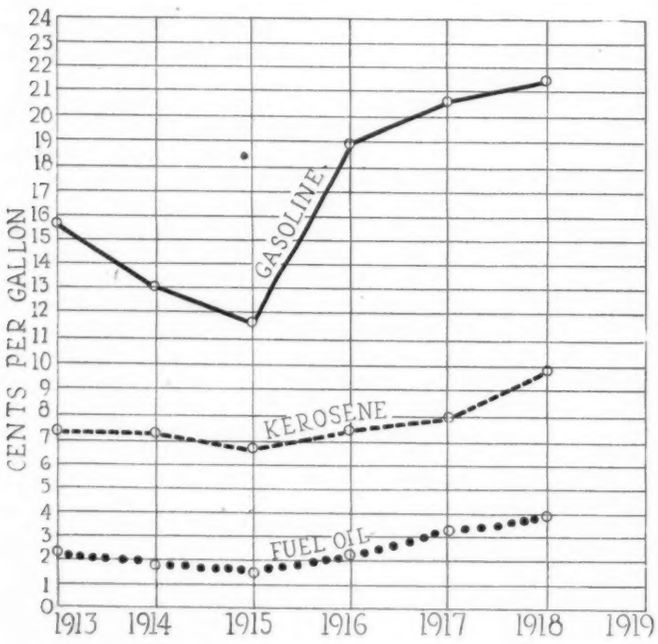


Fig. 2—The average wholesale price of gasoline, kerosene and fuel oil in 1913-1918. *Data from Oil Division, U. S. Fuel Administration and Price Section, Bureau of Planning and Statistics, War Industries Board*

and contributes by so much to the total supply. Information is wanting as to the exact contribution made by cracked gasoline, as the cracking operation is often an integral part of the ordinary refining process, and the records are not separately available.

Theoretically, the supply of gasoline can be doubled, or even trebled, from the same quantity of crude; but practically, the development and expansion of cracking processes are slow and it is estimated that it would require something like ten years for cracking to double the percentage of gasoline obtainable from crude over the average of 23 per cent now extracted.

In the meantime, other insistent demands bearing down upon fuel oil may be expected to lessen the price interval between fuel oil and gasoline, which is now the chief economic motive for the process. With engines adopted only to volatile gasoline, the automotive industry is now almost wholly dependent upon the competency of cracking to expand the fuel supply. Whether cracking can meet the issue fully without an undue increase in the price of gasoline (which, in fact, would not be meeting the issue) is open to question.

Additional Motor-Fuel by Lowering the Volatility of Gasoline.—It is common notoriety that gasoline during the past few years, especially during the past twelve months, has been becoming heavier and less volatile in quality. In this way, the total supply of gasoline has been increased at the expense of the lighter fractions of "kerosene" which went the way of motor-fuel instead of illuminating oil. This outcome is thought to be the normal economic response to a growing demand that the increases in crude production and the increments from natural gas and cracked fuel oils were unable to meet unaided. At any rate, lowering volatility is in actual progress and thus far the tide has not been stemmed, although the tendency has been widely frowned upon and excoriated.

Kerosene as Motor-Fuel.—Kerosene which sells now for about half the price of gasoline (see Fig. 2) is available for use as a motor-fuel (a) either directly as such, (b) after cracking into gasoline, or (c) through addition to the gasoline supply, which is thereby decreased in volatility.

There is a growing tendency, especially in the tractor industry, to use kerosene directly as a motor-fuel, but thus far its use in the gasoline engine cannot be said to have given generally satisfactory results. Cracking processes are under development which employ kerosene as their raw material, but the commercial practicability of such processes remain largely to be established; up to the present certain grades of fuel oil represent the dominant raw material from which cracked gasoline is produced.

The indirect use of kerosene through incorporation into the gasoline supply has already been adverted to; this use has already appreciably reduced the output of kerosene proper, but the engine in current use interposes a barrier to a practical extension of this expedient to embrace the entire kerosene cut.

Kerosene commands a lower price than gasoline merely because it cannot be so readily used for motor-fuel purposes. As soon as it assumes a parity in use, it may be expected to attain an equality in price.

Fuel Oil as Motor-Fuel.—Fuel oil is available as motor-fuel (a) directly in the heavy-oil engine of the Diesel or semi-Diesel types, (b) indirectly through the avenue of cracking into gasoline, and (c) directly in the current type of engine through the medium of gasification by means of heat.

As fuel oil is now almost exclusively used for steam-raising and gas manufacture—purposes for which coal would suffice—virtually the entire supply can be eco-

nomically captured by the automotive demand. Fuel oil is due for a rapid diversion to transportation purposes, and competition will rapidly develop between cracking, on the one hand, and a direct use, either in heavy-oil engines or upon gasification in light motors, on the other.

It remains to be seen whether this competition will result in a retardation in the development of cracking technique, the direct uses winning out; or whether cracking will prove competent to augment progressively the gasoline supply, the field of direct uses being accordingly narrowed by this counter demand. Upon the outcome will depend the course that engine development in the truck and tractor industries should take—whether the goal should be the heavy-oil engine, gasification apparatus, or a continuation of the present type of motor.

The whole matter, from the automotive standpoint, is complicated by the tremendous prospective upgrowth in the use of the marine motor burning fuel oil—a development that will encroach more and more upon the fuel oil supply at the same time that fuel oil is coming to be needed by automotive agencies on land.

SUPPLEMENTARY RESOURCES OF NON-PETROLEUM ORIGIN

With the tightening up of the gasoline situation, with its attendant problems as to the competency of cracking to maintain adequate increases in supply versus engine adaptation in the direction of accommodating the heavy fractions of petroleum distillation, there come into view a number of supplementary fuel resources such as benzol, alcohol, and shale-oil distillate, seeking a motor-fuel rôle. These fuels, or at least the first two, are now beginning to come upon the market, and although they were unable to compete with gasoline during the era of gasoline surplus, they now have possibilities of development as opposed to supplemental resources of petroleum origin, such as kerosene, fuel oil, and cracked gasoline. Whether these supplements can edge into use before crude petroleum is yielding up its full quota of motor-fuel values is an important question, the answer to which is contingent, in part, upon the fuel policy of the automotive industry.

Benzol as a Motor-Fuel.—Benzol is a light oil produced in commercial quantities along with coke, gas, ammonia, and tar, when bituminous coal is subjected to distillation in the by-product coke oven. The average yield is about 2½ gallons of benzol per ton of coal and roughly 1-12 of the bituminous coal mined in the United States is treated in this way.

The country's output of benzol has increased materially during the war, owing to the demand for this product in connection with the manufacture of explosives, resulting in a surplus of benzol now which must find an outlet in the form of motor-fuel. Increases over the present supply of benzol, however, are contingent upon the rate of progress in the by-product utilization of coal, which in turn is dependent upon the rapidity with which the beehive coke oven is replaced by the by-product oven in the coke industry, and the course of progress in the gas industry in the direction of supplying the fuel needs of communities under by-product practice.

At best, the benzol available for motor-fuel use must represent only a small fraction of the motor-fuel demand; but at the same time the quantity available must be reckoned with.

Benzol is a satisfactory fuel in the present type of engine, after a slight carburetor adjustment which is readily made. Fortunately it is miscible with gasoline, so that it may be used alone, mixed with gasoline, or alternating with gasoline. This feature greatly simplifies the problem of distribution.

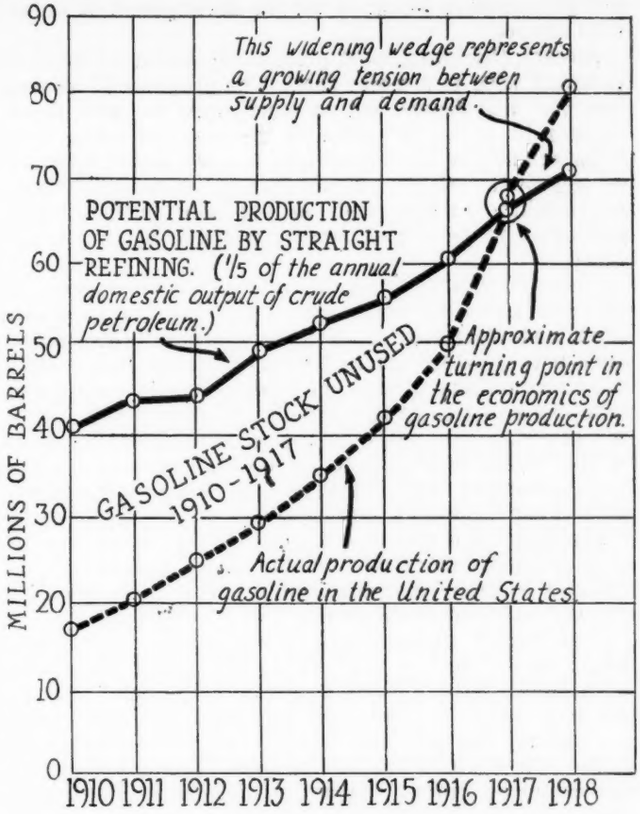

This widening wedge represents a growing tension between supply and demand.
POTENTIAL PRODUCTION OF GASOLINE BY STRAIGHT REFINING. (1/5 of the annual domestic output of crude petroleum.)
GASOLINE STOCK UNUSED 1910-1917
Approximate turning point in the economics of gasoline production.
Actual production of gasoline in the United States
MILLIONS OF BARRELS
0
10
20
30
40
50
60
70
80
90
1910 1911 1912 1913 1914 1915 1916 1917 1918

Fig. 3—Chart showing the tightening up of the gasoline supply in the United States. Data from Oil Division, U. S. Fuel Administration

Benzol is already coming on the market in small quantities in the eastern part of the country, selling at the same price as gasoline.

Alcohol as Motor-Fuel.—Alcohol stands apart from the fuels previously reviewed in the fact that it can be made from products of vegetable origin which are reproducable from year to year and therefore makes no drain on resources limited in quantity. As it constitutes a satisfactory fuel even in the present type of engine, and so far as raw materials are concerned can be manufactured in practically unlimited quantities, it offers a reassuring prospect in the face of a rapidly waning petroleum reserve.

Alcohol in composite form, mixed with benzol, kerosene, and other materials, has already come on the eastern market in small quantities; and manufacturers of industrial alcohol are making efforts to build up a motor-fuel demand for this substance.

The future of industrial alcohol as a motor-fuel remains to be seen. Thus far it has been unable to compete with gasoline, which was to be expected during the era of "easy" gasoline, especially as the cost of production, in the United States at least, has prevented a selling price in competition with gasoline.

With increasing facility in production, especially if the price of gasoline goes up a few cents, alcohol may be expected to assume increasing prominence; and it is an open question as to whether alcohol may not come into widespread use more rapidly than shale-oil distillate, its rival supplementary resource.

The legal difficulties in the way of widespread alcohol utilization, however, are to be taken into account as a retarding factor; although the coming in of Prohibition will free capacious manufactories for the production of industrial distillation products in the place of beverages

and give further incentive for the development of industrial alcohol.

Alcohol, therefore, must presumably sooner or later be reckoned with as a motor-fuel. The progress of alcohol, however, will depend not so much upon its own merits as upon its status in regard to the range of motor-fuels likewise undergoing development and the extent to which its upgrowth will fit into the general situation. These relationships have scarcely as yet been sufficiently investigated to permit of more definite statement in advance.

Shale-Oil Distillate as Motor-Fuel.—The occurrence in many parts of the country, especially in Colorado, Utah, and Wyoming, of immense areas of black shales, capable of yielding upon distillation appreciable quantities of an oil analogous to petroleum, has attracted considerable attention of late and offers a prospective source of motor-fuel. Oil-shale, indeed, is generally looked upon as the logical successor to petroleum, which will come into commercial development as soon as the richer petroleum resource needs a supplement.

Shale-oil cannot be produced as cheaply as petroleum at the present price level of the latter, although it is expected by many that moderate price advances over the present scale may bring shale-oil on a parity.

Considerable preliminary developments have already taken place over the past few years in Colorado and Utah particularly, but the progress of the new industry has been slow. At best, even granted a distinct need for output, the development of a large production of shale-oil must be a matter of many years, because of the extensive mining operations and large distillation plants that must come into existence as a preliminary.

Shale-oil will probably be able to yield a range of products roughly analogous to those extracted from petroleum, which is a very fortunate circumstance for the automotive industry, since engines developed for petroleum products will presumably prove suitable for shale-oil products. On the other hand, there is danger of a hiatus in supply, should petroleum output fall off more rapidly than shale-oil output develops; although a rapid development of fuel alcohol may stand ready to fill in the gap.

All these uncertainties, however, make it the more imperative that the automotive industry should adopt a fuel policy broad enough to care for all contingencies.

Composite Fuels.—Heretofore, automotive transportation has employed single fuels, chiefly gasoline. With the approach of supplementary fuels, and with progress in fuel research, the matter of mixed or composite fuels is assuming considerable interest. If it becomes necessary for the motor-fuel demand to be met by two or more fuels of diverse sources, the question of distribution will assume added importance, as to whether those fuels may be more advantageously marketed separately or as a blend.

It may turn out that a virtue can be made of a necessity, so to speak; for initial researches on mixed fuels have already gone to show that certain admixture may yield more favorable results than the components in severalty. Indeed, it is thought by some that results of almost revolutionary significance may be attained by intensive research in this direction following the trend of the economic situation in respect to motor-fuel production.

Up to the present, the field of composite fuels has been beclouded by a number of fakes and half-baked developments, to which an undue amount of publicity has been given. The industry will have to continue to be on its guard against falsifications in a field so little known and with possibilities so unsounded.

Significance of New Fuels Relative.—Since automotive transportation has developed and become standardized on the basis of gasoline, the significance of the various fuels coming into sight to supplement the gasoline supply does not depend upon the individual merits of the fuels so much as upon their capacity to enmesh with the existing situation.

A study of individual fuels, therefore, will prove misleading if not accompanied by an appraisal of the relationship that each bears not only to gasoline but to all other fuels that have potential motor use. This is one of the features which renders the motor-fuel problem

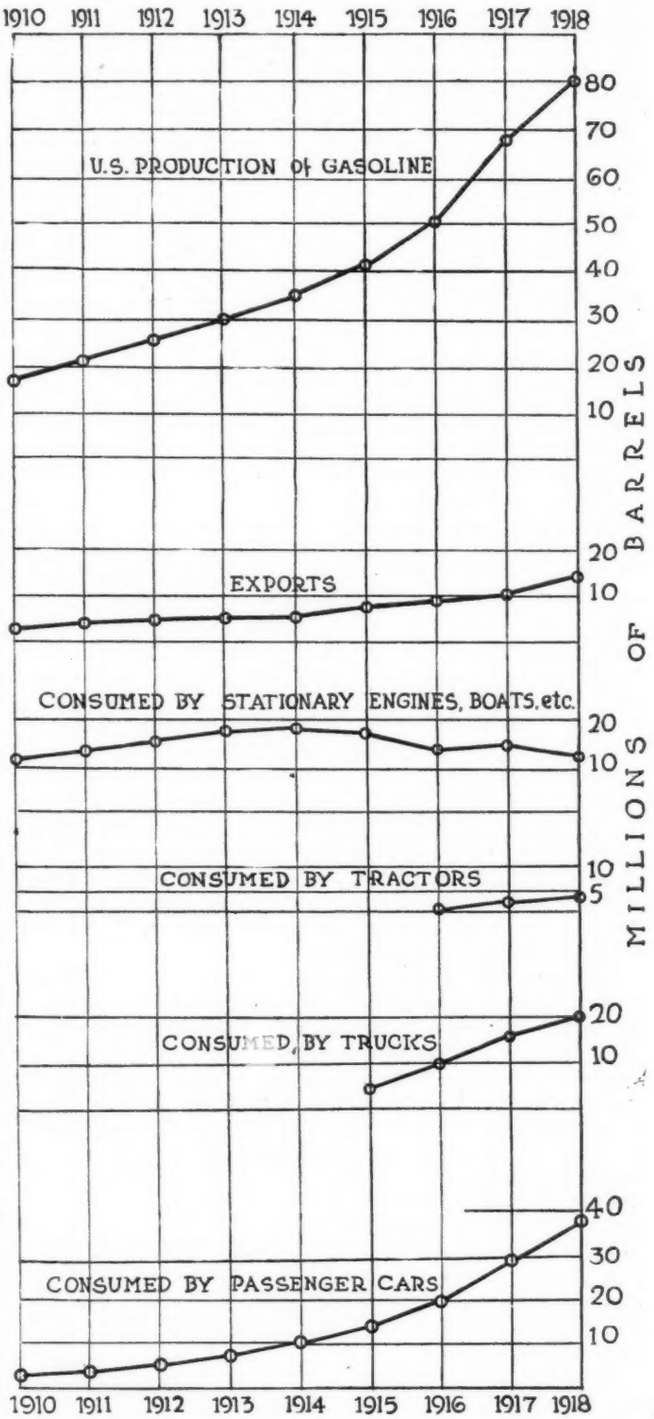


Fig. 4—Chart showing the rate of increase and character of the motor-fuel demand during 1910-1918. *Data from Bureau of Oil Conservation, Oil Division, U. S. Fuel Administration*

so intricate and so elusive if viewed with its various parts dissociated. It cannot be too strongly emphasized that the merits of any single factor in the situation, whether it be a process such as cracking, a new fuel undergoing development such as benzol or alcohol, a fuel in the offing such as shale-oil distillate or new types of mixed fuels, cannot be evalued unless cross-referenced with respect to all counter developments falling under its sphere of influence.

Such a condition renders a discussion of the situation peculiarly difficult, since the exigencies of language require that each topic be discussed separately, and all the due qualifications and cross-currents cannot be introduced without a fatal sacrifice of clearness and brevity. In visualizing the trend of the motor-fuel situation, therefore, the reader must hold in mind that the advance is not comprised of elements developing in parallel manner, but is more like a jostling crowd of components, each affected by the recurring impacts of all the others.

EVOLUTION OF THE MOTOR-FUEL SITUATION

If we view broadly the development of the automotive apparatus from a fuel standpoint, there appears to be an evolutionary trend behind the matter, with a bearing of considerable significance upon the issue under consideration.

Era of Engine Independence.—The era of gasoline surplus, when gasoline remained unextracted from a significant share of the output of crude petroleum, may also be termed the era of engine independence. The expansion in motor-fuel demand was then met by running a larger share of the crude petroleum through refineries, and the gasoline supply was maintained without sufficient change in quality to dictate adaptations in engine design. During that time, engine progress lay largely in the direction of refinements of quality—flexibility, power, convenience, etc. Fuel was standardized—a volatile gasoline—and the engine was independent of other fuel considerations.

Era of Superficial Concessions to Fuel.—During the past few years, a tightening up in the gasoline supply has become apparent, and in spite of various expedients for maintaining the gasoline of earlier days, a notable change in quality has come into evidence.

Gasoline has been getting heavier, less volatile, embracing an increasing quantity of material formerly produced as kerosene. This progressive change in gasoline quality is especially noticeable in winter, because of difficulties in starting engines, and during the past two winters in particular troubles on this score have passed the stage of inconvenience. So long as both fuel and engine remained standardized, all was well.

Now the fuel is undergoing de-standardization, so to speak, and the engine, built to use high-volatile gasoline, is forced to use low-volatile gasoline. Already, the engine has recognized this maladjustment, as indicated by superficial concessions to this state of affairs, as by preheaters, hot-spots, and the like, and by the upgrowth of a host of so-called fuel economy devices. The engine is now passing through an era of superficial concessions to the fuel situation.

Future Relation of Engine and Fuel.—Unless the present trend of motor-fuel reverses itself, the automotive industry will have to cope with a fuel growing progressively less specialized, or else with a diverging range of fuels, which comes to the same effect. The automotive industry, theoretically, can stop the change now taking place in fuel by holding fast to the present engine in detail, but this procedure will so limit the supply and increase the price of fuel that in practice the engine will have to give way.

It is concluded, therefore, that an era is arriving when the engine will have to make rather radical concessions to fuel, as a relief to a strained situation; and the problem before the automotive industry is: First, to recognize this situation; and second, to establish means for making these concessions with the maximum easement to the supply and price of fuel. Anything short of this will mean just so much of a detriment to the growth of automotive transportation.

A view of the rapidly increasing demand for motor-fuel, as shown graphically in Fig. 4, with reference to the limitating factors in supply as already noted, will emphasize the likelihood of conditions arising that will influence engine design.

Realization of a Motor-Fuel Problem.—The inevitable concern of the automotive industry in the motor-fuel situation is just coming to be appreciated. A year ago it was quite generally felt that fuel was a thing apart from automotive manufacture. Now the fuel situation is a live issue in the automotive industry.

The rise of a fuel problem, however, was not entirely unanticipated. For years the U. S. Geological Survey and the U. S. Bureau of Mines have pointed out the limited size of the petroleum resource and the need for its conservation.

In 1918, the Bureau of Oil Conservation of the Oil Division of the Fuel Administration made a special study of the motor-fuel situation and urged both upon the National Automobile Chamber of Commerce and the Society of Automotive Engineers that the matter be brought effectively to the attention of the automotive industry.

At the winter meeting of the Society of Automotive Engineers on Feb. 5, 1919, a morning was devoted to a fuel session, at which time a number of authoritative papers were presented, which served to outline the situation and call attention to the issue.[1] Following this meeting there has been a general agitation of the matter, and the topic of motor-fuel is now prominently before the automotive interests.

As a specific outcome of the meeting, a fuel research committee was appointed by the Society of Automotive Engineers, and this committee is now formulating plans for the establishment of a research organization charged with the duty of handling the fuel problem in behalf of the automotive industry.

SOLUTION OF THE MOTOR-FUEL ISSUE

Although the existence of a fuel problem is already generally appreciated, and preliminary steps have already been taken toward attacking the issue, there is danger that the true nature of the problem will not be apprehended and consequently a false start may be made.

While the problem is exceedingly complex when all its details are taken into consideration, the fundamentals appear to be sufficiently clear if the matter is logically analyzed. For example: Accepting the existence of a tightening-up tendency in the fuel supply as an obvious fact, there are two avenues of relief—increasing the efficiency of fuel utilization and enlarging the fuel supply itself. The first issue is a more direct matter than the second and may be more concretely handled, if concerted

[1]These papers were planned to give an authoritative expression of each important phase of the fuel problem, as follows:
1. The Unmined Supply of Petroleum in the United States, by David White, U. S. Geological Survey.
2. Mexico as a Source of Petroleum and Its Products, by E. DeGolyer, Consulting Geologist.
3. The Status of Refinery Practice in the United States, by E. W. Dean, U. S. Bureau of Mines.
4. The Status of Engine Efficiency in the United States, by H. C. Dickinson, U. S. Bureau of Standards.
5. An Interpretation of the Engine-fuel Situation, by J. E. Pogue, U. S. Fuel Administration.
6. More Efficient Utilization of Fuel, by C. F. Kettering, President of the S. A. E.

engineering effort and business policy is brought to bear intensively upon it.

In regard to increasing the fuel supply directly, however, the issue takes on a more intangible and elusive aspect. The curve of oil production is lagging behind the curve of motor-fuel demand, and consequently improved technology and supplementary resources must come into action if an unbroken advance is to be maintained.

But inadequate study has yet been brought to bear upon the relationship that the various fuels undergoing development hold to the fuel (gasoline) in current use, and therefore, to put the matter bluntly, relatively nothing is known of the real situation as it is shaping up. In other words, the problem has transgressed the bounds of the conventional methods of study and research heretofore employed; and unless new means are brought to bear upon the problem, no hope of a solution should be entertained.

Need for Scientific Control.—What is needed is an agency, representative of the automotive industry, competent to bring engine development into harmonious adjustment with fuel developments. This adjustment, of course, will ultimately be attained under the give and take of competition, but such an adjustment will prove slow and wasteful, and the industry, in the meantime, will be subject to retardation in event of fuel shortage. Instead of awaiting such an outcome, with its attendant vicissitudes, the automotive industry can take the matter in hand now and, by applying scientific method to the issue, insure itself against the evil effects of a period of fuel stress.

Means for Administering Scientific Control.—The fuel research organization now (June, 1919) undergoing formation is the obvious agency upon which the industry must depend for a solution of the fuel problem. Upon the vision and ability of this organization the success of the whole matter turns. It is of the utmost importance, therefore, that this organization be projected commensurate with the character and importance of the problem it is designed to solve.

The Functions of a Fuel Research Organization.—The fuel problem is not one which laboratory research alone can solve. The fuel situation must be explored and harmonious fuel policies must be developed, in addition to the work of research upon fuels and engines.

A fuel research organization, therefore, to be adequate, must accommodate three functions: economic analysis, to determine the course of fuel developments in relation to engine design; research, to build up the technology requisite to advance in fuel efficiency and fuel production; and industrial co-ordination, to insure an aggregate of fuel policies in adjustment with the needs of the fuel situation.[1] Only through an adequate organization, functioning in this three-fold manner, can the requisite efforts toward increasing thermal efficiency and enlarging the fuel supply be put forward by the automotive industry.

It cannot be emphasized too strongly that an ample supply of fuel depends not only upon the efficiency obtained in the engine from the fuel actually used, but also upon the efficiency attained in the realm of fuel production, which is contingent, in part, upon the requirements of the engine-type. It is the peculiar nature of the fuel problem to embrace the possibility of contributing to an easement of fuel supply in these two directions.

Difficulties in the Way of Progress.—There is a grave danger, at the present stage of affairs, that the true nature of the fuel problem will not be generally enough apprehended, and that a research organization too narrowly conceived to meet the issue will be established. This danger arises from the fact that a limited and narrow conception of the term "research" prevails, as being a matter entirely of material, laboratory investigations; while at the same time there exists a general tendency to overlook the fact that the fuel problem is primarily an *economic issue*, of which technology is only one factor.

Impossibility of Finding a Ready-Made Solution.—There seems to be a general feeling on the part of many in the automotive industry that a definite program for meeting the motor-fuel issue ought to be forthcoming. The point of view of the industry may perhaps be summarized in four questions.[2]

1. Are the gasoline producing companies doing all they can to produce the maximum motor-fuel from the available crude?

2. What must the automotive manufacturers do to obtain a greater percentage of efficiency from the fuel utilized?

3. What contemplated changes in fuel characteristics do the fuel producers expect will have to be made within the next five years?

4. What changes may this necessitate in the design of automotive apparatus?

It is felt by many that if answers to these questions could only be provided, the industry would then have a basis for action and could make definite progress.

In this light, however, it appears that an essential step in the problem—scientific exploration of the problem itself—is being quite universally overlooked. In the writer's opinion, no individual or organization in the country knows the answers to these questions. The answers have not been worked out. There has, indeed, been no agency engaged in working them out. If answers are necessary as a preliminary to action, the step immediately ahead is to establish an agency competent to bring adequate and rigorous scientific study to bear on the matter and to work out the answers.

In short, there appear to be three stages in the issue: First, the recognition that there is a fuel problem of concern to the automotive industry; second, the establishment of an organization for handling this problem under a true perception of the peculiar nature of the issue; and third, action. The first stage has been passed through; the danger now is that stage 2 will be too hastily attended to and that either the matter will lag for want of a convincing plan, or else lines of action will be followed leading off into impractical directions. The practical outcome, in fine, depends upon the type of motor-fuel research organization shortly to be established. This organization will either be equal to the occasion, or not; and if not, the immediate opportunity for progress will have been lost.

Confidence and Backing of the Automotive Industry Necessary.—It therefore behooves the automotive industry in its entirety to take the utmost interest and concern in the plans now under consideration for motor-fuel research. Without the financial support, confidence, and co-operation of the industry, a motor-fuel research organization cannot hope to go far. And conversely, without the existence of a central organization, built along broad lines and adequately equipped as to funds, personnel, and a true perception of the issue, the automotive industry will remain lacking in means for insuring its prosperity in the years immediately ahead.

[1] These three functions are elaborated in a paper, by the present writer, entitled "The motor-fuel problem," to be presented before the June Meeting of the Society of Automotive Engineers at Ottawa Beach and subsequently to be published in the Journal.

[2] This summary view was supplied the writer by David Beecroft in a letter of May 27, 1919

Automotive Export Problems During Post-War Period

The American Manufacturer Must Cultivate the Fields Opened to Him During Struggle to Offset Trade Lost by Allied Restriction — Figures of 1913 and 1918 Tell a Graphic Story

By Allen Sinsheimer

AMERICAN automotive manufacturers must completely readjust the world map of exports. There is little prospect of immediate renewal of the pre-war trade with the Allies. There is every possibility that the Allies will constitute formidable competition for export automotive business. Consequently, American manufacturers will find it particularly important to work closely those fields they have cultivated since 1914; guard against loss of business by meeting competition, and develop all possible new fields in the Orient and elsewhere before England, France, Germany and Italy are able to expand.

These conclusions come as a result of a study of the automobile exports of the various nations in 1913, and the recent disclosures, by Allied officials at the Foreign Trade and U. S. Chamber of Commerce conventions. Statements by these officials show that the United States cannot expect a resumption of pre-war automobile business with the large European nations for several years.

England, France and Italy, it was asserted, must control their imports until they re-establish their exports. They find themselves, to-day, after four years of war, exporting in April, 1919, $28,423,563 worth of products to the United States in return for $336,848,859 worth

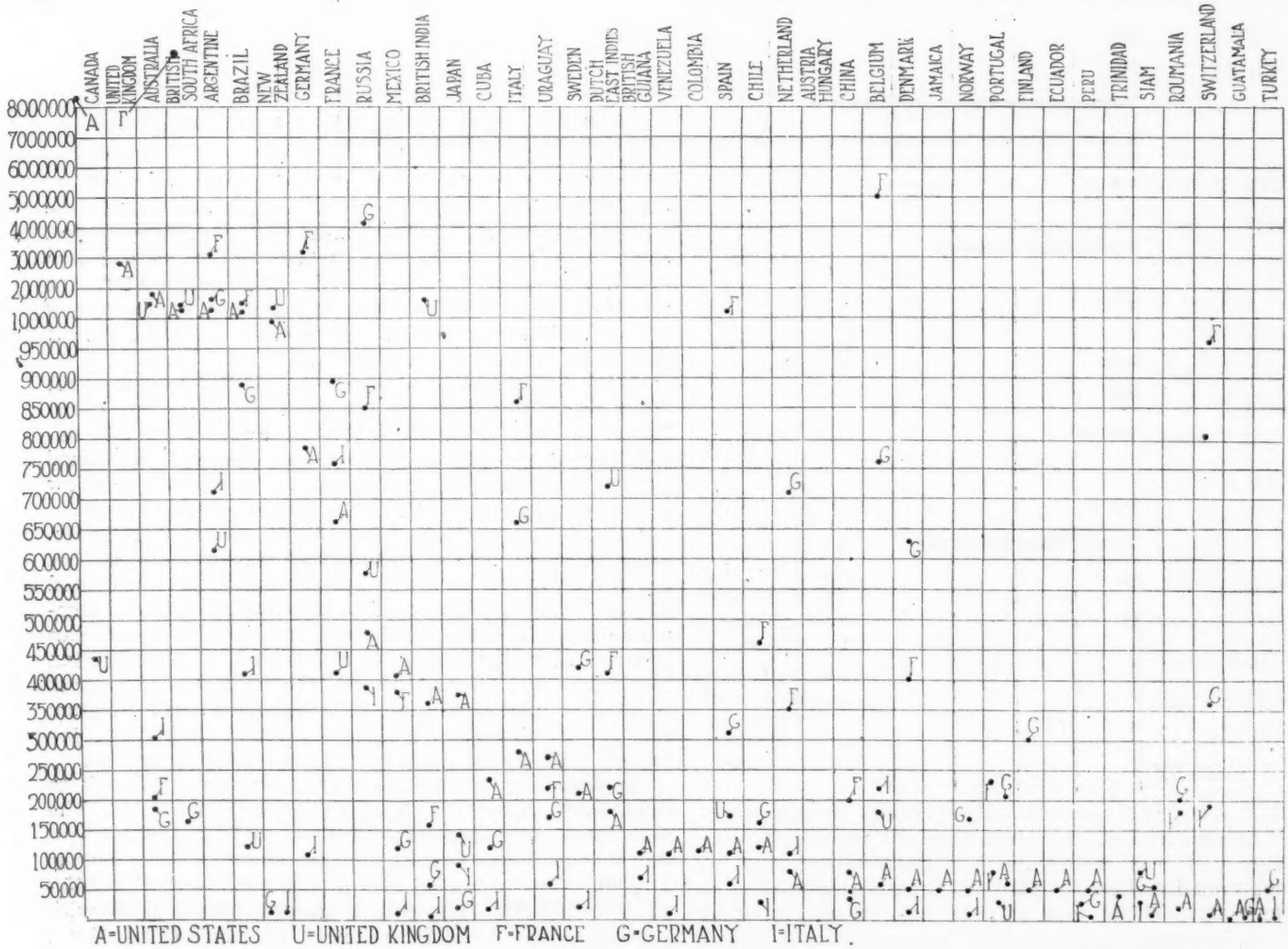


Chart 1—Showing the pre-war status of automobile shipments to the forty principal countries. France, Germany and the United Kingdom were very frequently larger exporters to certain countries than was the United States

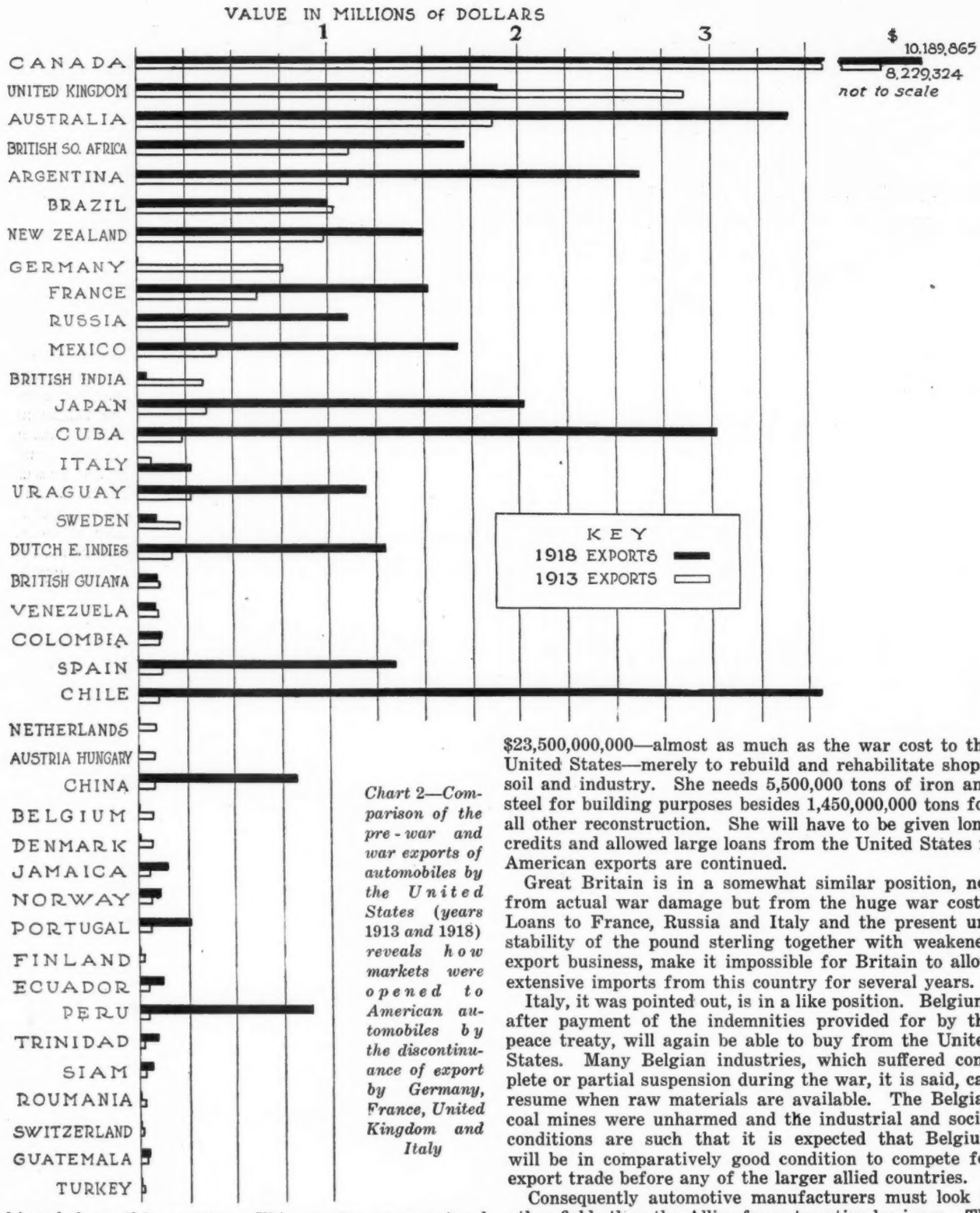


Chart 2—Comparison of the pre-war and war exports of automobiles by the United States (years 1913 and 1918) reveals how markets were opened to American automobiles by the discontinuance of export by Germany, France, United Kingdom and Italy

shipped from this country. This creates an unnatural trade balance and an unhealthy financial situation.

France, it was stated, is in such condition that it cannot even intelligently plan its future at present. It is short 222,000,000 tons of coal, has 250,000 miles of road to be repaired, needs 2500 locomotives and 35,000 freight cars, has $5,000,000,000 circulating in paper money against $772,000,000 gold deposit, will require $23,500,000,000—almost as much as the war cost to the United States—merely to rebuild and rehabilitate shops, soil and industry. She needs 5,500,000 tons of iron and steel for building purposes besides 1,450,000,000 tons for all other reconstruction. She will have to be given long credits and allowed large loans from the United States if American exports are continued.

Great Britain is in a somewhat similar position, not from actual war damage but from the huge war costs. Loans to France, Russia and Italy and the present unstability of the pound sterling together with weakened export business, make it impossible for Britain to allow extensive imports from this country for several years.

Italy, it was pointed out, is in a like position. Belgium, after payment of the indemnities provided for by the peace treaty, will again be able to buy from the United States. Many Belgian industries, which suffered complete or partial suspension during the war, it is said, can resume when raw materials are available. The Belgian coal mines were unharmed and the industrial and social conditions are such that it is expected that Belgium will be in comparatively good condition to compete for export trade before any of the larger allied countries.

Consequently automotive manufacturers must look to other fields than the Allies for automotive business. The war completely upset the conditions of 1913. In Chart No. 2 it is shown that the export of automobiles by the United States increased from $24,275,793 in 1913 to $45,331,360 in 1918. The gain represents chiefly trade with countries which could no longer be supplied by Great Britain, Italy, France or Germany. As an example, our exports to Argentina increased from $1,181,735 in 1913

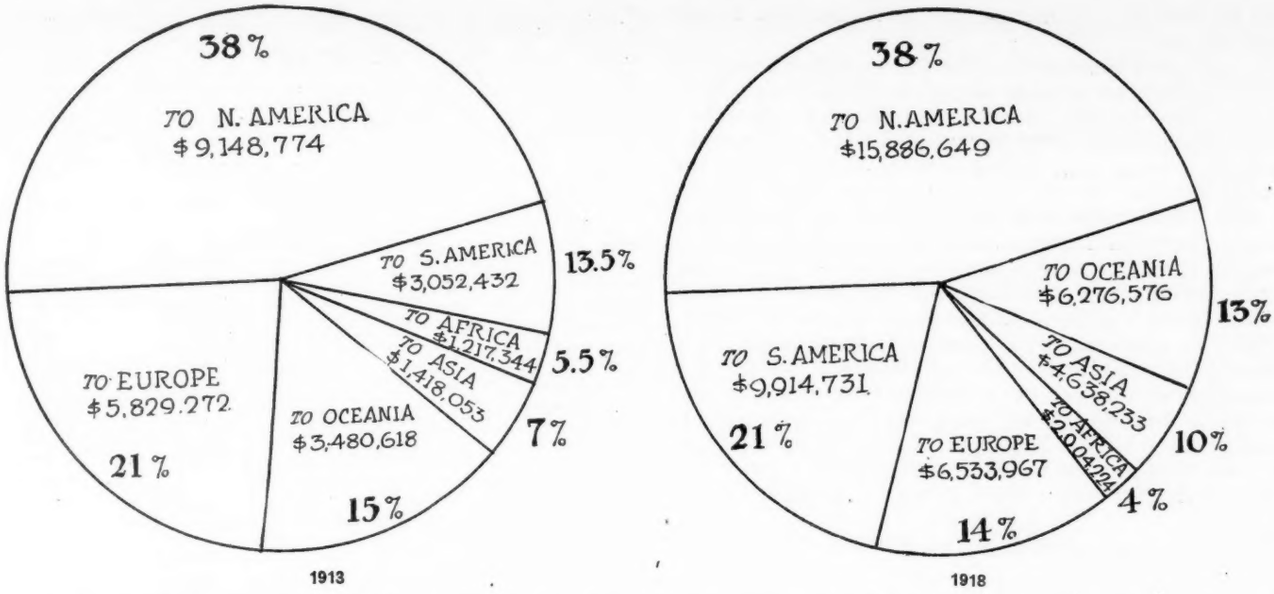


Chart 3—Shipments of automobiles to North American countries were not affected by the war. South America assumed the position in 1918 that had been held by Europe in 1913, taking 21 per cent of the total exports, while Europe took but 14 per cent

to $2,666,898 in 1918; to Uruguay from $273,253 to $1,177,463; to Cuba from $242,686 to $3,029,813; to Chile from $109,982 to $3,576,511; to China from $90,459 to $830,997; to Spain from $127,621 to $1,346,826; to Dutch East Indies from $198,378 to $1,302,800, and to Peru from $55,646 to $913,669.

Prior to the war, as is shown by Chart No. 1, Chile purchased its automobiles chiefly from France, which shipped $606,926 worth of vehicles there in 1913; secondly from Germany, and thirdly from the United States. China made its greatest purchases from France; the Dutch East Indies from the United Kingdom, France second, Germany third, and the United States fourth. Argentina purchased chiefly from France, next from Germany and thirdly from the United States. The United Kingdom obtained its greatest imports from France and next from the United States.

By continents (chart 3) the exports of 1913, compared with 1918, show a steady increase of exports from the United States to North American countries. Exports to South America increased from 13.5 per cent to 21 per cent, while the exports to Europe decreased from 21 per cent to 14 per cent, indicating that the war had so shifted the exports to South America as to recompense American manufacturers for their losses in Europe. Africa, although increasing its exports, did not maintain a proportionate growth. Oceania, including Australia, the Philippine Islands and New Zealand, increased its purchases

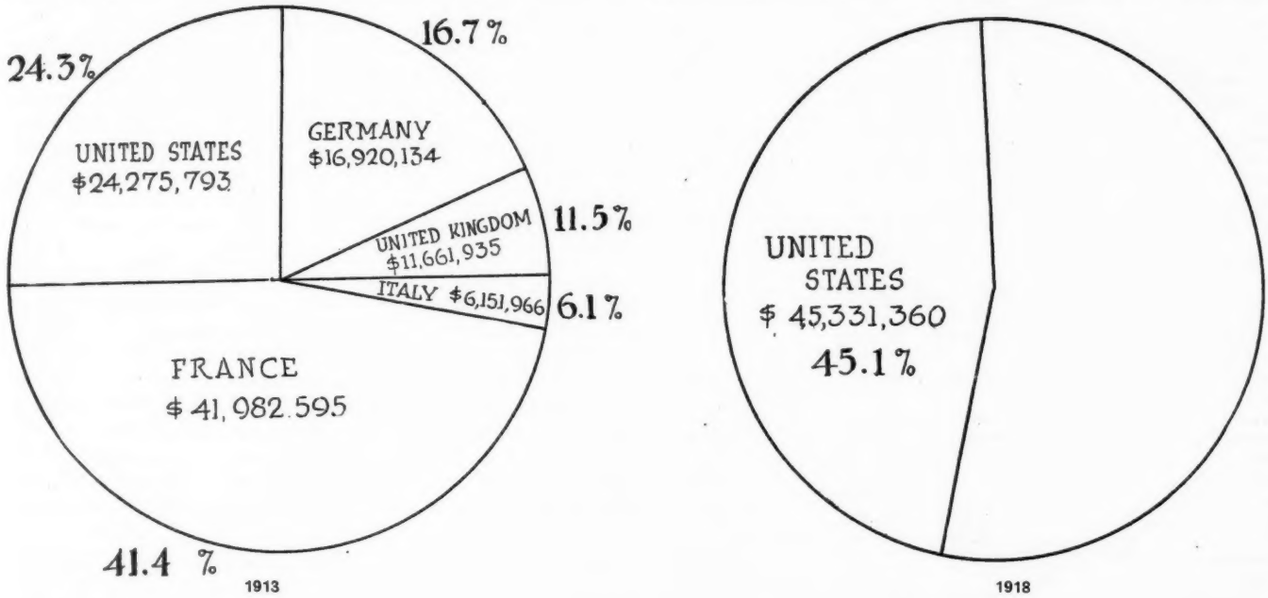


Chart 4—The positions of the various automobile exporting nations in 1913 are clearly indicated in the above chart, which shows that France exported 41 per cent of the total as compared with 24.3 per cent shipped by the United States. With the entire world markets open, the United States shipped only $4,000,000 more of automobiles in 1918 than France exported in 1913

both in value and percentage, due to its inability to buy from Europe.

The problem consequently for the manufacturer is to develop export business among these countries to make up for losses caused by restrictions imposed by the Allies. Great Britain has temporarily allowed the American manufacturers to ship to that country 50 per cent of the number of cars sent there during the first seven months of 1913. This permission ends Sept. 1. It means that comparatively few automobiles will be exported, and those most likely will be used as demonstration and sales cars.

What will happen after Sept. 1 is problematical. It is not yet known whether Great Britain relaxed restrictions to meet the demand for passenger cars from this country temporarily, until the British manufacturers can get into production, or whether the relaxations will continue, but the wise manufacturers will base export plans on nations other than the United Kingdom. There is no prospect of business with France, which is maintaining a strict embargo, or Italy which cannot afford to buy automobiles abroad.

The most fertile fields appear to lie in South America, the Orient, neutral countries of Europe and in British South Africa. The problem rests completely on whether or not American manufacturers will be able to hold the trade gained during the war. For instance, can the American exporter hold the business of Argentina, formerly held by France and Germany; or in Mexico which originally divided purchases between the United States, France, Germany and Italy; or Spain, which, prior to the war, purchased automobiles chiefly from France?

Spain, Portugal and the Scandinavian countries are prosperous and likely fields for American sales. The Scandinavian countries favor the United States. They disliked the strict censorship of Great Britain and the hardships imposed upon them by Germany during the war. Spain and Portugal, after four years' dealing with the United States, recognize and appreciate American merchandise, and the American manufacturer has an opening in these fields to-day, with a slight advantage over the Allies, who enjoy a better location, with more prompt supply facilities.

British South Africa, which prior to the war purchased its automobiles chiefly from Great Britain, and secondly from the United States, imported $1,706,136 worth of cars from this country last year, more automobiles than it purchased in any one year from Great Britain. To hold and increase this business will demand intensive effort from American manufacturers. Great Britain will make an earnest attempt to recover her export trade in British South Africa. It is a British colony, and has the advantage of cheap parcel-post rates from Great Britain.

The Latin-American countries demand special concentration and attention from Americans. It is in this field that the losses of exports to Europe can be balanced. Argentina, Brazil, Uruguay, Venezuela, Colombia, Chile, Ecuador and Peru are buying all of their automotive products from the United States. American manufacturers and Latin-American dealers and consumers have come

Value of Germany's Car and Truck Exports

To	Passenger Cars		Trucks	
	1908	1913	1908	1913
Argentina	$50,456	$1,228,080	$20,701	$55,644
Australia	13,566	159,460	.....	67,144
Austro-Hungary	421,022	1,720,026	53,074	281,316
Belgium	35,700	768,978	31,178	2,856
Brazil	35,224	857,038	.....	493,850
British India	.....	76,398	.....	33,082
British Malacca	.....	6,188	.....	.....
British South Africa	.....	159,460	.....	.....
Bulgaria	.....	75,446	.....	29,512
Ceylon	.....	34,986	.....	.....
Chile	.....	152,558	19,990	19,516
China	.....	49,504	.....	.....
Cuba	.....	138,516	.....	19,040
Denmark	39,270	625,226	13,094	28,084
Dutch East Africa	.....	.....	30,702	18,088
Dutch East Indies	40,698	218,960	.....	27,846
Egypt	.....	11,424	.....	.....
Finland	.....	305,830	.....	99,960
France	499,800	868,93[illegible]	12,614	15,232
Greece	.....	29,036	.....	32,368
Guatemala	.....	12,138	.....	.....
Italy	48,076	655,448	32,368	88,964
Japan	.....	42 602	.....	.....
Kamaroon	.....	.....	.....	13,566
Kiao-Chau	.....	17,136	.....	.....
Mexico	.....	142,324	.....	33,558
Morocco	.....	.....	.....	138,010
Netherlands	36,652	723,758	.....	71,368
New Zealand	.....	12,852	.....	.....
Norway	22,134	167,790	.....	42,364
Peru	.....	17,374	.....	.....
Portugal	15,946	215,390	.....	2,380
Roumania	78,064	214,200	.....	231,098
Russia	415,548	4,232,116	151,130	778,736
Serbia	.....	24,276	.....	116,144
Siam	.....	51,884	.....	7,616
Spain	43,078	347,430	.....	.....
Sweden	33,558	435,540	13,566	.....
Switzerland	73,780	369,614	.....	37,128
Turkey	.....	51,408	.....	101,864
United Kingdom	429,590	1,214,752	18,564	104,720
United States	64,974	245,616	.....	50,456
Uruguay	.....	172,312	.....	.....
All other countries	98,294	58,072	43,316	71,638
Total	$2,495,430	$16,920,134	$440,300	$3,316,126

Cars and Trucks Exported by United Kingdom

	1908		1913		1917	
	No.	Value	No.	Value	No.	Value
Argentina	.....	.....	304	$622,333	1	$1,460
Australia	.....	.....	1055	1,693,625	30	43,988
Belgium	15	$30,464	154	194,903	.....	.....
Brazil	.....	.....	77	136,739	8	5,042
British India	.....	.....	1223	1,845,352	124	337,273
Ceylon and dependencies	.....	.....	178	277,887	3	8,010
Straits Settlements	.....	.....	285	423,79[illegible]	55	69,592
British Possessions, N. E. S.	297	458,468	381	587,464	160	150,750
British South Africa	.....	.....	934	1,399,255	26	34,250
Canada	.....	.....	169	445,338	3	5,596
Denmark	.....	.....	.....	.....	27	68,339
France	52	113,638	419	426,685	113	187,900
Germany	7	25,062	.....	.....	.....	.....
Italy	.....	.....	.....	.....	.....	.....
Japan	.....	.....	69	128,992	1	4,287
Java	.....	.....	77	148,574	5	6,472
New Zealand	.....	.....	829	1,192,760	30	39,949
Portugal	.....	.....	27	56,286	.....	.....
Russia	2	4,137	429	558,703	658	2,031,406
Siam	.....	.....	42	59,942	.....	.....
Spain	.....	.....	120	164,142	23	58,967
United States	23	66,871	76	290,013	31	180,762
Others	38	87,597	747	1,009,108	260	346,685
Total	434	$786,237	7595	$11,651,935	1588	$3,610,758

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France's Car and Truck Exports

French automotive exports are recorded in pound weight instead of by units or values for individual countries. The following table thus permits of comparison by weights only. The year's total value in dollars is also given.

	Passenger Cars (Lb.)			Trucks (Lb)	
	1908	1913	1915	1913	1915
Algeria	1,191,185	5,484,604	344,799	155,865	6,393
Argentina	956,444	4,079,171	173,061	208,776	.....
Australia	.....	301,589	.....	.....	.....
Austria-Hungary	74,079	300,928	.....	.....	.....
Belgium	2,545,667	9,665,407	.....	535,056	.....
Brazil	471,165	1,858,257	56,438	410,496	.....
British India	.....	221,562	250,663	.....	40,565
Canada	.....	.....	.....	65,697	24,471
Chile	.....	606,926	73,193	.....	.....
Colombia	.....	.....	.....	75,177	.....
Denmark	133,720	541,891	67,681	254,852	.....
Dutch East Indies	.....	576,503	90,609	.....	.....
Egypt	208,694	354,720	74,075	.....	.....
Germany	2,395,178	4,685,436	.....	546,961	.....
Greece	.....	.....	140,213	59,304	91,490
Indo-China	258,855	297,401	197,973	30,203	3,307
Italy	480,667	1,315,705	1,132,723	169,754	39,021
Japan	.....	.....	8,598	.....	.....
Madagascar	.....	106,041	.....	.....	.....
Mexico	503,014	489,421	.....	77,662	.....
Morocco	.....	677,033	162,920	214,728	91,050
Netherlands	2 8,965	456,132	204,807	.....	.....
Norway	.....	.....	46,958	.....	.....
Portugal	87,765	690,922	207,894	69,445	.....
Russia	733,528	1,550,275	4,688,302	80,688	.....
Spain	626,699	1,583,328	874,785	129,190	3,086
Switzerland	425,439	1,143,967	77,602	.....	27,337
Tunis	326,087	694,670	103,616	71,870	.....
Turkey	143,780	.....	.....	.....	41,00
United Kingdom	13,460,441	13,319,532	3,179,254	147,488	.....
United States	2,425,702	749,123	663,144	45,856	.....
Uruguay	.....	324,738	.....	.....	.....
All other countries	467,186	1,207,018	204,366	233,026	44,974
Total lb	28,064,278	53,284,300	13,023,674	3,708,578	457,763
Value in dollars	$24,568,654	$41,982,595	$13,111,696	$1,914,753	$353,149

to a closer co-operation and understanding. South America is now so completely accustomed to American cars, so thoroughly prepared to make and adjust repairs and maintain American cars, that this business, which increased from $3,052,432, in 1913, to $9,914,731 in 1918, should be easily maintained and extended. There is little likelihood that Argentina, for example, will again turn to France or Germany for automobiles in preference to the United States product, if American manufacturers will study the habits and customs of the Argentine folk, and meet them with honest, fair, and intelligent business.

It is likely that Australia, which, prior to the war, purchased its automobiles in slightly greater quantities from the United States than from Great Britain, and which increased its purchases from $1,896,990, in 1913, to $3,410,557 in 1918, will continue to buy chiefly from this country unless the trend of the trade is changed by restrictions.

Similarly with New Zealand, which increased its purchases from the United States 50 per cent during the war. Before the war this was chiefly British trade. It is possible for American manufacturers to hold this gain.

Briefly, therefore, the problem confronting the American automobile exporter is to develop further those countries which turned to the United States during the war, to head off European competition, and particularly to study each individual market exhaustively, to learn its requirements so thoroughly that the foothold that Ameri-

Value of Italy's Car and Truck Exports

To	Passenger Cars			Trucks		
	1908	1913	1915	1908	1913	1915
Albania	.....	.....	$229,863	.....	.....	.....
Algeria	.....	$19,204	.....	.....	.....	.....
Argentina	$571,087	725,131	77,779	.....	$30,969	.....
Australia	105,185	320,959	329,787	.....	3,474	$52,110
Austria-Hungary	342,548	247,600	11,387	.....	386	38,600
Belgium	12,738	207,475	211,528	.....	.....	124,755
Brazil	44,583	398,510	28,564	.....	49,369	.....
British India	1,544	9,650	146,574	.....	1,544	100,360
British South Africa	.....	.....	.....	.....	772	.....
Bulgaria	.....	27,599	11,580	.....	.....	.....
Central America	16,019	5,115	.....	.....	.....	.....
Chile	5,394	41,665	15,633	.....	3,860	3,860
Cuba	.....	26,634	17,756	.....	.....	.....
Denmark	.....	3,860	9,650	.....	.....	.....
Dutch East Indies	14,475	86,946	151,601	.....	.....	13,124
Ecuador	.....	1,448	.....	.....	.....	.....
Egypt	14,089	2,316	1,544	.....	.....	.....
Eutrea	3,474	1,544	.....	.....	.....	.....
France	598,676	748,454	1,023,189	$5,465	14,282	4,792,865
French Asiatic Colonies	.....	3,474	.....	.....	.....	.....
Germany	555,587	118,058	199,562	.....	1,737	45,838
Greece	2,316	15,857	65,967	.....	42,267	77,200
Italian Somaliland	.....	1,930	386	.....	.....	3,474
Japan	4,825	79,806	19,493	.....	.....	.....
Malta	6,755	2,895	.....	.....	.....	.....
Mexico	.....	13,317	.....	.....	.....	.....
Montenegro	.....	15,054	.....	.....	.....	.....
Morocco	.....	4,632	4,632	.....	.....	.....
Netherlands	66,585	117,344	33,582	.....	1,158	.....
New Zealand	.....	2,895	.....	.....	.....	.....
Norway	.....	15,054	43,040	.....	.....	.....
Peru	.....	5,790	.....	.....	.....	.....
Portugal	3,800	79,516	16,453	.....	.....	215,967
Portuguese Africa	.....	1,075	.....	.....	.....	.....
Roumania	2,895	184,508	75,849	.....	.....	188,175
Russia	55,102	385,923	822,277	.....	216,160	523,416
Salvador	.....	.....	2,316	.....	.....	.....
Serbia	.....	18,528	4,246	.....	.....	.....
Siam	.....	1,930	6,948	.....	5,970	3,474
Spain	23,259	71,796	89,601	.....	.....	127,573
Spanish Africa	.....	13,124	.....	.....	.....	.....
Straits Settlements	.....	21,230	25,832	.....	.....	.....
Sweden	.....	17,352	12,352	.....	.....	.....
Switzerland	1,030,458	219,523	65,331	63,304	10,914	16,984
Tripoli	.....	20,643	2,895	.....	44,236	.....
Tunis	2,895	.....	.....	.....	.....	.....
Turkey in Asia	3,860	.....	.....	.....	.....	.....
Turkey in Europe	42,508	33,601	.....	.....	15,722	.....
United Kingdom	1,296,670	1,396,207	1,184,909	.....	.....	587,492
United States	663,534	182,983	44,766	3,860	.....	.....
Uruguay	3,860	53,804	30,108	.....	2,316	.....
Total	$5,449,692	$6,151,966	$5,310,000	$72,629	$444,956	$6,915,267

Italy's Exports Are Classified as Follows:

Weight (Kilograms*)	Value		
	1908	1913	1915
Passenger cars:			
Under 500	$104,317	$10,461	$7,262
500-1,000	1,812,193	2,282,225	1,204,687
Over 1,000	3,533,182	3,859,280	4,105,313
Trucks:			
Under 1,000	1,544	28,477	334,855
1,000-3,000	44,030	369,927	5,765,180
Over 3,000	26,055	46,552	815,232

*Kilogram = 2.2406 lb.

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can manufacturers have gained will be extended. If the American manufacturers ignore the requirements of the individual countries they may take it for granted that England, Germany, Italy and France will quickly recover their losses.

The automobile business formerly held by Europe is not to be despised. In 1913 Germany exported $16,920,134 worth of automobiles and $3,316,126 worth of trucks; France, $41,982,595 worth of passenger cars and $1,914,753 worth of trucks; Italy, $6,151,968 worth of passenger cars and $414,956 worth of trucks, and the United Kingdom, $11,661,935 worth of passenger cars and trucks, a total of $82,362,465, as compared with $24,275,793 worth of passenger cars and $1,737,141 worth of trucks which were exported by the United States. These huge exports were made before Europe learned the massed production that has come out of the war, and it is a certainty that unless the American manufacturer employs all his skill, not only in production but also in engineering and merchandising, he will find the export automobile business going back into old channels.

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ITALIAN TRACTOR DEMAND

WASHINGTON, June 10.—Italian demand for tractors will be slight in the immediate future, according to a report by Commercial Attaché A. P. Dennis. The government purchased a heavy stock in the country during the war and there are now 6000 American tractors in Italy, while outstanding contractors with domestic concerns call for 1500 more. The sales to individual farmers are negligible. The government purchases the tractors and sends them out in squadrons of ten in charge of a non-commissioned military officer, who plows for farmers in the vicinity at so much per acre.

The plowing is quite unlike the customary American methods. The conventional plow in the plains of Lombardy is a heavy implement, ordinarily of German manufacture, with a moldboard from 18 to 21 in. deep and a superimposed jointer for the better spreading of the deep upturn of land. The combined effort of 8 to 12 oxen is required to operate this plow, and when a heavy type is used the services of two men are also required.

The weighty army tractors, which have been tried out for this service, are not adapted to the work, as two of the wheels must run either in the furrow or on the turned earth, whereas all the heavy-bearing wheels should track on the unturned soil. The reason for plowing to the depth of 20 in. is to conserve moisture.

United States Exports of Passenger Cars

	1908	1913	1918
Europe:			
Austria-Hungary	*4* $3,218	*134* $91,781	.....
Azores & Madeira Is.	.....	*16* $10,549	.....
Belgium	*14* $36,900	*94* $85,679	.....
Bulgaria	.....	*17* $11,457	.....
Denmark	*10* $9,045	*81* $77,149	*2* $4,100
Finland	.....	*51* $53,568	.....
France	*191* $669,405	*818* $615,086	*1,169* $1,518,858
Germany	*68* $171,293	*845* $764,389	.....
Gibraltar	.....	*7* $6,576	.....
Greece	.....	*5* $4,080	*4* $6,580
Iceland and Faroe Is.	.....	*2* $1,016	*15* $11,396
Italy	*73* $243,744	*331* $280,961	*129* $78,228
Malta, Gozo & Cyprus Islands	.....	.....	.....
Netherlands	*19* $43,699	*111* $94,163	.....
Norway	*3* $5,751	*78* $66,689	*97* $115,810
Portugal	*1* $1,226	*73* $58,931	*223* $270,987
Roumania	*3* $4,941	*38* $30,337	.....
Russia in Europe	*32* $37,243	*580* $484,913	*492* $1,136,400
Serbia, Montenegro & Albania	.....	*2* $1,160	.....
Spain	*5* $3,855	*186* $127,621	*1,205* $1,346,826
Sweden	*16* $20,409	*256* $235,918	*95* $111,377
Switzerland	*1* $608	*22* $24,965	*3* $1,533
Turkey in Europe	*1* $807	*13* $9,814	.....
England	*757* $1,621,516	*3,783* $2,893,785	*742* $1,712,672
Scotland		*6* $8,104	*150* $217,000
Ireland		*6* $5,538	.....
North America:			
Bermuda	*1* $1,800	.....	.....
British Honduras	.....	*1* $1,800	*8* $6,858
Canada	*385* $700,504	*6,723* $8,229,324	*12,985* $10,189,865
Central American States:			
Costa Rica	*2* $1,336	*13* $14,955	*199* $85,070
Guatemala	*6* $11,550	*10* $14,892	*34* $46,657
Honduras	.....	*4* $8,100	*16* $12,292
Nicaragaua	.....	.....	*49* $32,031
Panama	*7* $4,926	*39* $43,432	*129* $93,329
Salvador	*1* $1,700	*11* $13,212	*54* $68,297
Greenland	.....	.....	.....
Mexico	*244* $354,338	*235* $423,123	*2,578* $1,653,545
Miquelon, Langley & St. Pierre Islands	.....	.....	.....
Newfoundland & Labrador	*2* $6,500	*9* $10,353	*27* $34,676
West Indies, British:			
Barbados	.....	*7* $5,793	*58* $33,198
Jamaica	.....	*62* $59,131	*236* $149,673
Trinidad & Tobago	*28* $45,866	*43* $39,902	*161* $100,571
Other British	.....	*7* $6,716	*80* $50,009
Cuba	*105* $157,081	*233* $242,686	*2,846* $3,029,813
Danish (Virgin Is. of U. S.)	.....	*4* $2,131	*152* $12,313
Dominican Republic	*1* $2,000	*7* $5,382	*248* $157,607
Dutch	.....	*19* $14,590	*12* $7,435
French	.....	*5* $3,877	*248* $146,698
Haiti	.....	*38* $24,499	*102* $54,613

	1908	1913	1918
South America:			
Argentina	*70* $72,396	*1,062* $1,181,735	*3,525* $2,666,898
Bolivia	.....	*2* $1,493	*152* $105,408
Brazil	*55* $97,363	*987* $1,035,247	*1,575* $1,000,011
Chile	*15* $20,045	*78* $109,982	*3,399* $3,576,51
Colombia	*1* $500	*110* $113,334	*164* $121,422
Ecuador	*4* $2,453	*74* $55,372	*148* $130,086
Falkland Is.	.....	.....	.....
Guiana, British	*1* $765	*18* $114,313	*180* $100,546
Dutch	.....	.....	*16* $17,775
French	.....	*1* $558	*8* $3,632
Paraguay	*1* $557	.....	*13* $5,025
Peru	*8* $6,790	*70* $55,646	*784* $913,669
Uruguay	*8* $13,142	*209* $273,253	*2,238* $1,177,463
Venezuela	.....	*104* $109,499	*160* $97,485
Asia:			
Aden	.....	*15* $7,998	*8* $6,879
China	*7* $7,471	*89* $90,459	*833* $818,659
China, British	.....	.....	*6* $3,000
China, French	.....	.....	*2* $2,017
China, Japanese	.....	.....	*10* $7,321
Chosen (Korea)	.....	*7* $6,095	*2* $1,300
East Indies, British:			
British India	*11* $9,970	*439* $355,573	*73* $53,428
Straits Settlements	*16* $12,625	*387* $319,247	*287* $202,221
Other British	*2* $1,375	*39* $31,245	*11* $17,740
Dutch	*117* $79,989	*278* $198,378	*1,272* $1,302,800
French	.....	.....	*18* $21,175
Hongkong	*3* $2,308	*7* $6,673	*117* $9,122
Japan	*7* $17,230	*312* $364,507	*2,149* $2,040,897
Persia	.....	.....	*2* $1,048
Russia in Asia	.....	*1* $1,160	*5* $8,425
Siam	*5* $2,959	*56* $35,934	*65* $60,220
Turkey in Asia	.....	*1* $824	.....
Oceania, British:			
Australia	*87* $74,175	*2,083* $1,896,990	*4,307* $3,410,557
New Zealand	*59* $72,647	*958* $990,837	*1,818* $1,453,311
Other British	.....	*3* $2,396	*30* $20,863
French	.....	*11* $14,005	*12* $7,612
German	.....	*1* $350	*12* $11,029
Philippine Islands	*16* $14,897	*517* $577,040	*1,714* $1,373,204
British Africa, West	.....	*4* $2,688	*202* $115,772
South	*2* $1,147	*1,279* $1,157,895	*2,143* $1,706,136
East	.....	*14* $12,802	*112* $75,778
Canary Islands	*1* $1,426	*10* $6,426	*15* $5,378
Egypt	*1* $3,500	*16* $10,156	*21* $17,300
French Africa	.....	*10* $7,297	*121* $50,550
German Africa	.....	*5* $3,175	.....
Italian Africa	.....	.....	.....
Liberia	.....	*1* $805	*12* $4,220
Madagascar	.....	.....	*2* $1,659
Morocco	.....	.....	*35* $17,718
Portuguese Africa	.....	*20* $16,102	*9* $9,673
Totals	*2,477* $4,656,991	*24,293* $24,275,793	*52,312* $45,331,360

The figures in *italics* denote the number of passenger cars exported to each country.

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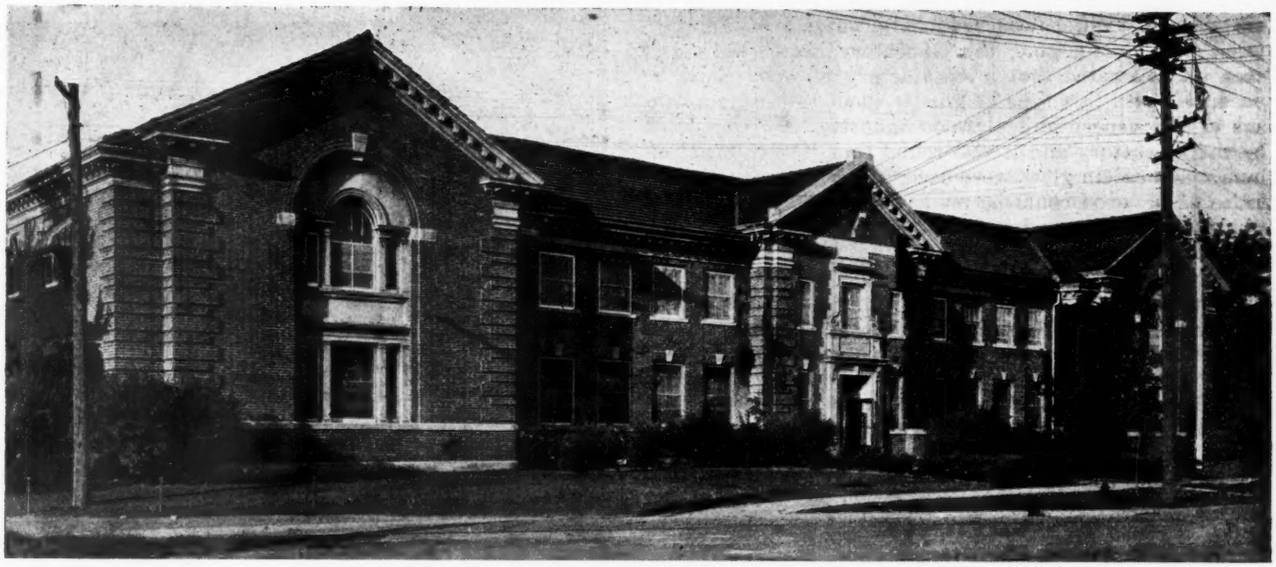


Main building, Forest Products Laboratory, Madison, Wis.

Waterproof Plywood for Airplanes

Decision to Build DH-4 Machine in This Country Created Large Demand for Plywood—Waterproof Glue the Chief Technical Problem Involved—Strength Tests Made

WHEN plywood was recognized as a structural material for use in aircraft early in 1917, it became necessary immediately to insure its production in quantity and to improve the quality of the commercial product. Before the war plywood was made up with vegetable or cheap animal glues, neither of which was water resistant. Attempts had been made in a small way both in this country and abroad to introduce waterproof plywood made with blood albumin glue, but its use was not general and the methods of manufacture were more or less trade secrets. The first investigations of the U. S. Forest Products Laboratory at Madison, Wis., had shown that the commercial water resistant glues in this country were scarce and unsatisfactory. In fact, only four or five of those submitted by various manufacturers were even promising.

Late in 1917 the decision to build the DH-4 model in this country created a demand for large quantities of waterproof plywood, and it appeared that the supply of waterproof glue would be the controlling factor in the production of this material. Accordingly at the request of the Army and Navy Aircraft bureaus, the Forest Products Laboratory attacked the problem from the following angles:

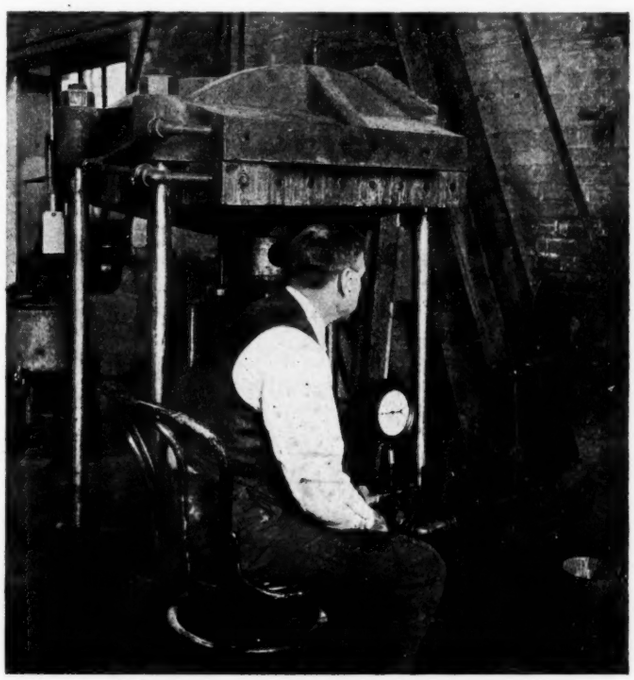
(1) Development of water resistant glues and assistance in securing their manufacture in quantity.

(2) Development of testing methods for water resistance and strength of glues and performance of routine tests on samples sent in by inspectors and manufacturers.

(3) Recommendation of glue and plywood specifications.

(4) Study of the properties of plywood as a material.

Investigation of the quantity production possibilities of water resistant glue made it very soon apparent that the supply of blood albumin would be inadequate and that if blood albumin glue only were used, the cost of the plywood would be extremely high. Meanwhile, having found



Gluing an experimental plywood panel with blood albumin glue. The press is steam heated and hydraulically operated

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one company which was producing water resistant plywood with casein glue, the laboratory began work and soon demonstrated that a satisfactory plywood could be produced with this type of glue. About this time a census of the veneer and plywood industry was completed by the laboratory and it was found that if both blood albumin and casein glues were used, almost unlimited quantities of plywood could be made. The general situation was therefore relieved and the price of plywood steadily reduced.

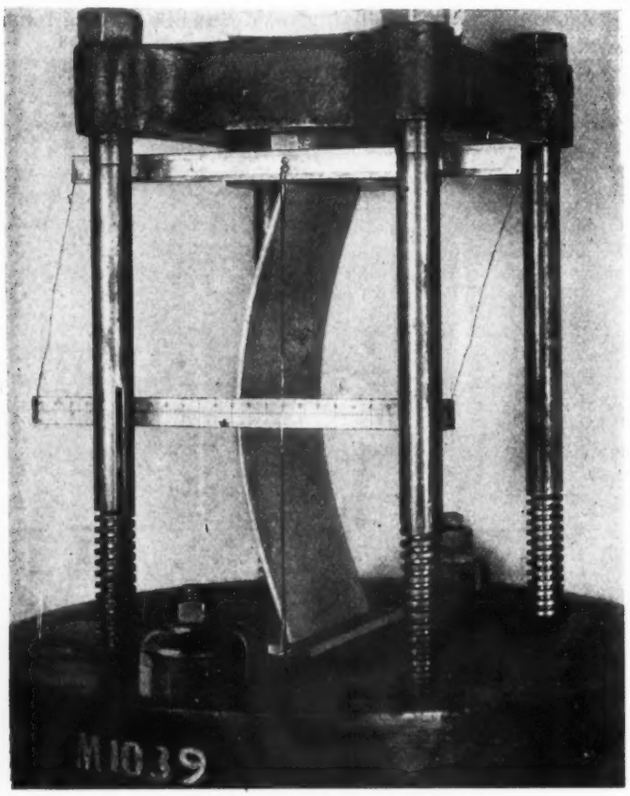
Aircraft manufacturers at this time showed a decided preference for non-waterproof plywood and it was only because the Forest Products Laboratory could supply information on the possible production of the waterproof product, together with data upon its advantages here and abroad, that waterproof specifications were adopted. It appears probable that the adoption of the non-waterproof specifications would have resulted in very few of the machines constructed from plywood reaching Europe intact.

By this time the Signal Corps had completed the organization of a plywood inspection section, and the laboratory was receiving samples of plywood almost daily from new manufacturers who desired their product tested.

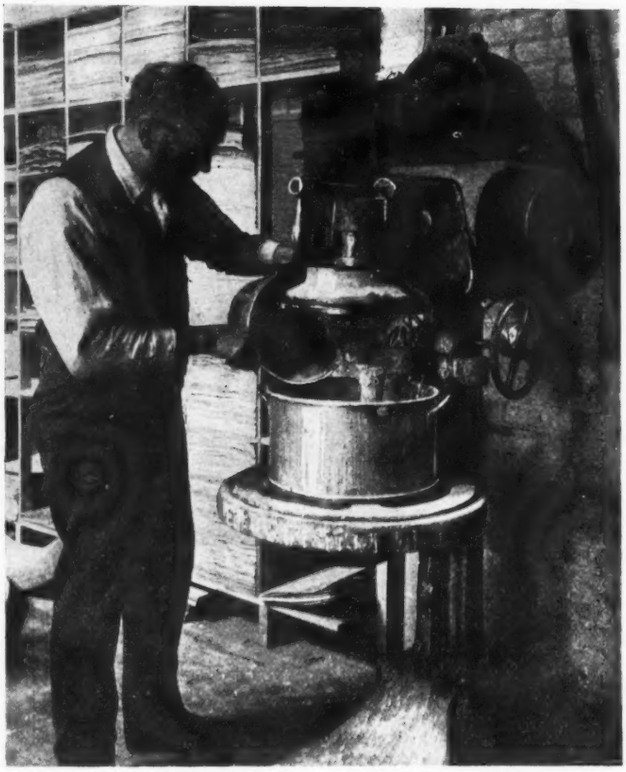
A glue inspection organization had also been started and headquarters established at the Forest Products Laboratory with a senior inspector from the Signal Corps in charge. The glue inspection force worked in close cooperation with the laboratory in the matter of glue specifications and procedure for inspection and certification of aircraft glues.

Work was under way on the development of casein glues and contact with casein producing companies and glue manufacturing companies had become well established.

During April, 1918, two commercial water-resistant casein glues were tested for shear strength in joint work



Strength test of veneer panels



Mixing a full-sized batch of casein waterproof glue

and they both developed strength equivalent to that of high grade non-waterproof hide glue. Two water-resistant glue formulas developed by the laboratory had also been supplied to certain manufacturers of glue and plywood and numerous companies were becoming interested in waterproof plywood manufacture.

During the summer of 1918 a method of gluing very thin plywood was developed and demonstrated on a commercial scale at two plants by representatives of the laboratory. The process involved the coating of tissue paper with blood glue, drying this sheet and using it with the veneer instead of a wet glue. This material was not found as suitable a substitute for linen as it first gave promise of being and but little of it was manufactured. A similar process was developed for gluing the linen fabric on propellers and satisfactory blood albumin tapes were also developed for use in taping plywood.

While the work which has been described was under way at the laboratory, additional activities of a less spectacular nature were also having their effect upon the improvement of quality and increase in production of water resistant plywood. Methods of manufacturing casein and blood albumin were investigated and specifications prepared for these and other glue constituents. Improvements were also suggested for glue manufacture and use, especially along the lines of mixing and applying glues, testing samples of plywood for strength and water resistance when sent in by manufacturers and Bureau of Aircraft inspectors, training of these inspectors in glue and plywood manufacture and solving specific problems submitted by various departments of the army and navy aircraft bureaus.

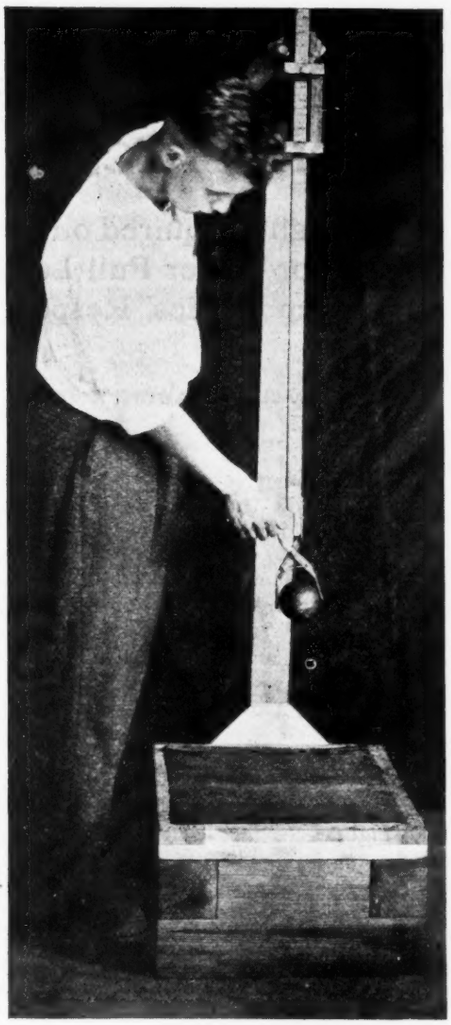
The wide distribution of the results of this work was especially helpful to manufacturers. Experts from the laboratory also made trips into the field and on numerous occasions "trouble men" were sent out to panel factories for periods ranging from a few days to one month. Their work ranged from correcting the practice of mix-

ing a glue or adjusting a press to a complete analysis of all factors of production to locate some small but important trouble.

The total result of the work of the laboratory on water-resistant glues and plywood may be summarized by saying that it practically meant the developing of a new industry, the improvement of its product to the essential degree and the saving of more than $6,000,000 to the Government by removing scarcity of plywood as a controlling factor in aircraft production.

Plans for an extensive series of tests to determine the physical and mechanical properties of plywood were drawn up in September, 1917, and the testing was begun early in October of the same year.

In outlining a series of tests for plywood, the attempt was made to test for those properties of plywood that make it a unique material of construction for airplanes. Inasmuch as the strength of plywood depends upon the direction in which the forces act, tests were made to determine the bending and tensile strength, parallel and perpendicular to the face of the panel. A piece of apparatus was devised for determining the relative resistances to splitting of plywood made of various combinations of veneer. Tests were also made to determine the relative resistances of various plywoods with conditions that tend to warp the plywood, as, for example, wetting on one face. In a series of tests to determine the physical and mechanical properties of plywood made of various species of veneer panels of eight thicknesses were tested, ranging in thickness from 3/30 of an inch to 3/6 of an inch. Moisture and density determinations were made on all test specimens. One series consisted of about fifty (50) tests and to date more than one hundred (100) series of tests have been made, which covered about thirty (30) species.



Toughness test on thin plywood

In addition to the extensive series of tests on various species of plywood, tests were also made on plywood consisting of combinations of several species of veneer; also on plywood consisting of five, seven and nine plies. Reports were issued from time to time embodying the results of the strength tests. On the basis of the tests made a specification for plywood was drawn up and submitted to the Specification Section of the Bureau of Aircraft Production. The list of species recommended included several species that had not previously been used and that the tests showed to be satisfactory, and omitted other species that were not as satisfactory.

A classification of species into four (4) groups was also drawn up. This classification gives a brief description of the mechanical properties of the species grouped and points out specific uses for airplane parts for which particular species would be satisfactory.

Detailed recommendations were made from time to time governing the species to use for particular airplane parts made of plywood. A plywood table was drawn up, giving the species, thicknesses, position of plies and number of plies to use for each plywood panel in the USD-9 airplane. Similar tables were prepared for the DeHaviland-4 and the Lepere planes.

The tests initially made to determine the relative resistances of plywood to weathering made of various species of veneer proved to be unsatisfactory, so another test was devised. In the latter test the panels were subjected to high humidities to change their moisture content and subsequently they were exposed to brilliant sunshine to lower their moisture content. Warping measurements were made at various stages. These tests showed that as a rule the species of low density were inclined to warp less than the species of high density. The tests also showed that a high ratio of core to total plywood thickness is also favorable to a reduction of warping. Panels in which the center ply is of low density veneer also warp less than panels in which the center ply is of high density veneer of the same weight.

A series of tests to determine the relative strength of screw and nail fastenings of plywood was inaugurated. The tests completed to date show that screw fastenings were generally superior to nail fastenings even when the nail used is twice as long as the screw. The tests also show that the strength of fastenings increase with the density of the plywood.

A series of tests to determine the shear strength of plywood was started. Tests have been completed on plywood in which the distance between the shear forces and width of the member was varied. The shear strength of plywood parallel to the grain of face, while not very much higher than the shear strength of the wood parallel to the grain, is nevertheless superior to the latter, inasmuch as sudden failure does not occur. A lower factor of safety may consequently be used when designing plywood parts that are subject to shear. Shearing strength of plywood when the force is exerted at 45 deg. to the direction of grain of face is stronger than wood parallel to grain of face and advantage has been taken of this fact in designing plywood members. Tests are still in progress to determine the shear strength of plywood made of various species of veneer and to determine the relative shear strength of plywood made of various numbers of plies. An extensive series of tests to determine the bearing strength of plywood made of various species of veneer and various numbers of plies is now in progress.

The effect of varying the sizes of the bolt, the thickness of the plywood and the direction in which the force is applied are being investigated.

A series of tests to determine the effect of the method of cutting veneer on the strength of plywood was completed. These tests were made on five species in which veneer was cut from the same log by each of three processes. They show that in general the method of cut-

(*Continued on page* 1359)

The Influence of Hitches and Drawbar Location on Tractor Design

A Method of Calculating the Weight Required on the Front Wheels to Prevent Rearing of the Tractor Under Full Load, on the Level and on Steep Grades, Respectively

By A. W. Scarratt*

SEVERAL articles have appeared in the automotive magazines in the past few months which show the importance of proper drawbar implement hitches and how to make them, but nothing has appeared, to the writer's knowledge, which explains clearly the influence of hitches and drawbar location as related to tractor design. The purpose of this article is to cover this subject, as related to the four-wheel-type of tractor or modern design, in simple language and figures.

Let us consider first the case of a tractor doing plowing on tough, level land, equipped with an engine capable of delivering 30 hp. maximum at the flywheel, and weighing, completely equipped, 4500 lb., or 150 lb. per brake horsepower.

In order to determine the required weight distribution, we must first endeavor to compute the probable maximum drawbar pull and to establish its point of application. Two factors enter here, namely, speed or rate of travel, and efficiency. Two hundred feet per minute or 2.27 miles per hour is a good lively plowing speed for heavy work, and the efficiency or drawbar power consists of what is left after we deduct the rolling resistance of the tractor, the transmission losses, and the slippage at the drive wheels.

These three items can be approximated as follows:

1. Rolling resistance about 15 per cent of engine power.
2. Transmission losses—about 12 per cent of engine power.
3. Slippage—about 8 per cent of engine power.

Slippage is one thing often lost sight of and it is easy to lose sight of 8 per cent. That is just a nominal slippage. You can hardly notice it.

Adding up these three losses, we find that 35 per cent of the engine power has disappeared and that we have 65 per cent left to work with, which if converted into drawbar pull means 3200 lb. at a speed of 200 ft. per minute. This, therefore, is a three- to four-plow tractor, depending on the ground conditions, and being of compact, enclosed, modern design it will operate with the right-hand drive wheel in the furrow.

On a tractor designed to operate as stated, the drawbar should be located at least 14 in. above the bottom of the drive wheels—for two reasons:

First, to attach to the plow at a proper height.

Second, to have a reasonable ground clearance beneath the drawbar.

We now have the information necessary to proceed with the design of the tractor, namely, the weight of the tractor, the drawbar pull, the height of the drawbar, and the speed.

*EDITOR'S NOTE.—A. W. Scarratt is tractor engineer for the Minneapolis Steel & Machinery Co., and as such has given special attention to the subject of tractor hitches.

By referring to Fig. 1 we find that there are a number of forces both active and reactive to be considered, and our object is to determine the magnitude and position of these forces in order that the system will balance, for in order to obtain equilibrium the moments of the active and reactive forces must be equal.

The one active force with which we are concerned is the tangential load applied at the rim of the main drive gear which tends to raise the front end of the tractor; this is indicated by F_1. In order to overcome the opposing loads the moment of this force must be greater than the moments of the forces acting against it.

We have assumed that the transmission loss is 12 per cent., or 4 per cent for each of three gear reductions. Then the power delivered at the rim of the main gear would be 92 per cent of the engine power, or 27.6 hp. As we are considering a slippage of 8 per cent, the speed of 200 ft. per minute is only 92 per cent of the rim speed of the drive wheels, which we will assume to be of 26 in. radius. In other words, the actual rim speed is 217 ft. per minute. Since in this case the radius of the main gear is 13 in., or one-half of the wheel radius, the pitch line velocity of the gear is 108.5 ft. per minute.

Therefore the force at the pitch line of the main drive gear—

$$F_1 = \frac{\text{Hp.} \times \text{constant}}{\text{velocity}} = \frac{27.6 \times 33{,}000}{108.5} = 8400 \text{ lb.}$$

This force naturally tends to lift the front end of the tractor and is only prevented from doing so by two reactive forces, namely, the drawbar pull W_1 and the front end weight W_2.

We know the position, direction and magnitude of W_1, and we also know the position and direction of W_2. What we want to know is the required magnitude of W_2.

It will be well to notice here that these forces all center about the rear axle, that all tendency to rotate is about the rear axle, and not the point of contact between the drive wheels and the earth. Therefore all moments must be computed, using the rear axle as the fulcrum point.

Then since the active and reactive forces are equal and opposite,

$$F_1 \times 13 = (W_1 \times 12) + (W_2 \times 84)$$
$$\text{or } 8400 \times 13 = (3200 \times 12) + (W_2 \times 84)$$
$$\text{or } 109{,}200 = 38{,}400 + (W_2 \times 84)$$
$$\text{or } 70{,}800 = (W_2 \times 84)$$
$$\text{from which } W_2 = 850 \text{ approximately.}$$

That is, W_2 must be 850 lb. in order to keep the tractor from overturning on level ground. This, however, provides no necessary weight for steering the tractor, and makes no allowance for the increased weight which is necessary when operating on heavy grades.

In a three-plow tractor there should be a surplus of about 400 lb. weight at the front end to permit of proper guidance at all times and also as an extra safeguard against overturning.

It may be well to mention here the fact that when the load is picked up very suddenly by engaging the clutch too rapidly, the power transmitted momentarily is far in excess of the maximum engine power. It is equal to maximum engine power plus the power derived from the stored-up energy in the flywheel. This condition, due to careless operation, has tipped many tractors over which would be safe if properly handled. But careless operation will be encountered and tractors must be made fool-proof as far as possible.

From the foregoing it will be seen that the location and intensity of the drawbar pull have a very definite influence on tractor design.

But the example just covered is not the one which governs, so let us consider the operation of the tractor on a heavy grade of say 30 per cent, as other conditions are met with here.

Now, maybe you think 30 per cent is not a heavy grade. Well, the next time you are out plowing up and down a hill that you guess is about 50 per cent, just get a long timber and a spirit level and find out what it is; chances are that it will be about 25 or 30 per cent.

To start with, the efficiency of the tractor will not be as high; that is, you will not have 65 per cent of the engine power available at the implement, for the following reasons: More power will be required to roll the tractor up hill against the force of gravity, the footing will most likely not be as good, causing increased slippage, and the heavy implement itself must be dragged up hill against the force of gravity, thereby absorbing a great portion of the power which was available at the drawbar on the level.

We assumed previously that the rolling resistance of the tractor itself would be 750 lb. on level ground. The rolling resistance on a 30 per cent grade will be just 1350 lb. more, making the total draft 2100 lb. for this 4500 lb. tractor, provided the ground surface is just as good. With an increase in wheel slippage to 12 per cent we find that the drawbar pull has dropped to 34 per cent of the engine power, or 1700 lb., the losses being as follows:

Rolling resistance	= 42 per cent
Transmission losses	= 12 per cent
Slippage	= 12 per cent
Total	66 per cent

By referring to Fig. 2 you will note that we still have force $F_1 = 8400$ lb., and we also have force W_1, but it is now only 1700 lb., hence we are going to need more front end weight.

We must now endeavor to determine this weight, but we shall have to first assume what we think would have been a correct front end weight in Fig. 1. Let us take this to be 1700 lb. Then the center of gravity (fore and aft) would be 32 in. ahead of the rear axle. However, when standing on a 30 per cent grade this dimension is reduced to 27.8 in.

Now we will assume that W_2 acts downward 27.8 in. ahead of the rear axle.

$$\text{Then } F_1 \times 13 = (W_1 \times 12) + (W_2 \times 27.8)$$
$$\text{or } 8400 \times 13 = (1700 \times 12) + (W_2 \times 27.8)$$
$$\text{or } 109{,}200 = 20{,}400 + (W_2 \times 27.8)$$
$$\text{or } 88{,}800 = (W_2 \times 27.8)$$

From which $W_2 = 3200$ lb., or the weight required to prevent the tractor from overturning on a 30 per cent grade. Since the center of gravity is 32 in. ahead of the rear axle when the tractor is on a horizontal plane, the resulting weight at the front wheels would be 1220 lb., which leaves a balance of 480 lb. overweight for steering when we have a total of 1700 lb. at the front end.

It is, therefore, very clear that the later case governs the design, and it should also be clear that to arrive at a correct tractor design the drawbar and its location must be carefully and primarily considered.

Incidentally, this also shows clearly the marked advantage which a light-weight, powerful tractor has when operating in hilly country, as compared to the average tractor which weighs about 300 lb. per brake horsepower of the engine. If the tractor considered in this article weighed 300 lb. per brake horsepower, or 9000 lb., it could barely propel itself up the grade considered.

As plowing is the heaviest work which a tractor is called upon to perform, the drawbar location for this class of work should be most favorable. A vertical adjustment at the tractor will hardly be required, but a sideways adjustment should be provided by all means in order that the plow may be hitched to the best advantage regardless of the number of bottoms, and right here it will be well to remember that what may be a four-plow tractor in some places is a two-plow tractor in others.

For discing, harrowing and seeding it would probably be advantageous to be able to hitch at a higher level than for plowing. There are many implements of this type in use intended to be horse-drawn which could easily

(*Continued on page* 1359)

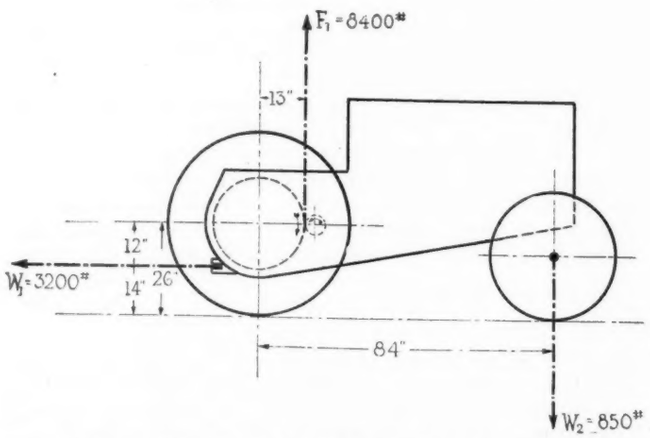


Fig. 1—Diagram of forces on tractor when operated on level ground

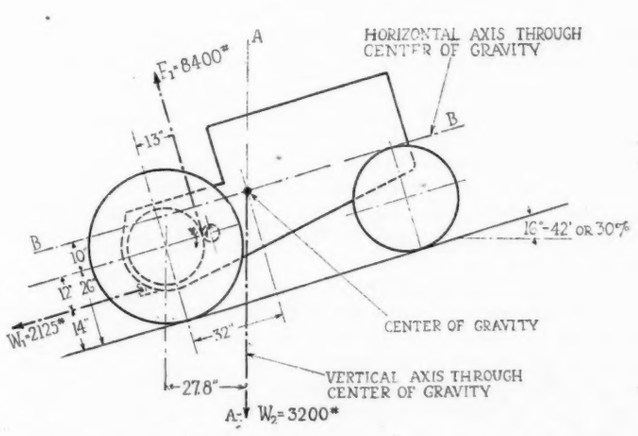


Fig. 2—Diagram of forces when tractor is on 30 per cent grade

Humanity Becomes Important Factor in British Labor Settlements

Review of Developments of Conferences Representative of Workers, Capital and Government in Post-War Period Indicates a Political Growth Not Yet Achieved in This Country

By Harry Tipper

THE developments in Great Britain between the signing of the armistice and the present time have emphasized the predominance of the economic problem and particularly the industrial problem in the political life of the country. They have indicated the development of additional strength in the labor power and at the same time an increasing division between the radical element in the labor organization and the more experienced conservative majority.

The most important points to be considered in connection with the development are:

1. **The demands of the manufacturer in respect of labor.**
2. **Findings of appointed commissions representing government, labor and capital.**
3. **The growth in power of the shop stewards.**
4. **The organization of the radical division of labor in favor of industrial unions instead of occupational unions.**
5. **The promotion of the Whitley plan by the Government.**
6. **The definite tendency to shorter hours.**
7. **Lack of any considerable wage reductions.**
8. **Continuance of a large proportion of unemployed.**
9. **Difficulty in industrial readjustment and the consequent partial activity in industry.**
10. **Large developments in housing**
11. **Strong definition and consolidation of labor aims.**

The labor organizations in Great Britain have been sufficiently developed industrially and were sufficiently powerful politically to necessitate the careful consideration of their position during the war in order to provide the necessary unity for industrial war activity. The occupational unions, in the most important industries, have been recognized as the necessary machinery for effective bargaining, for a great many years, and they represented a sufficient majority of the workers in many of the industrial lines, particularly in the skilled trades required for war work, so that the Government was obliged to call them in in order to secure the orderly progress and production to the point necessary for war development.

As a consequence of this, the older organizations were directly concerned in the methods and operation of labor dilution by the introduction of women employees, in the release of essential workers, in the elimination of the usual labor privileges accorded by shop practice in England, and it became necessary in the Government controlled industries to appoint committees of labor and capital to go over the war operations of these industries.

In return for this co-operation, the labor organizations demanded from the Government an agreement that all trade union privileges would be restored upon the termination of the war and that no attempt would be made to hold the workers to the concessions which had been secured from them for war necessities. In the agreements these privileges were specifically mentioned and the Government was committed to the practical enforcement of the return of these privileges at the termination of the war.

Combined Committees of Labor and Capital

In addition to these specific agreements, the Government had been obliged to develop combined committees of labor and capital in the controlled industries and had been obliged to concede additional power to the labor organizations in several ways. It had further promised, more or less vaguely, to consider the living conditions, the housing necessities and other matters in which labor organizations were interested, when the termination of the war would permit these developments. Part of the present confusion in Great Britain is due to the difficulty which the Government is having in redeeming its pledges to the labor party and the labor organizations.

In the endeavor to fulfill some of its promises and to bring about an orderly adjustment to peace conditions the Government appointed, after the armistice, the commission to investigate the coal miners' demands and the national council, as recommended in the Whitley plan, to consider the whole industrial question. These two commissions are the first examples of triangular conferences of labor, capital and Government which have had their beginning in the political demands and practical necessities of the worker, and which have recommended definite, and in some cases drastic, changes, carrying the recommendations of the commissions much further than settlement of the immediate question.

The action of the Sankey commission was the direct result of the coal strike which started in the Welsh coal field and extended to various other coal fields in Great Britain, involving nearly 140,000 miners. The strike did not involve the Scottish miners, this union standing at one side to await the result of the negotiations of the English and Welsh unions with the Government.

Coal Miners' Demands

The coal miners' strike involved more important demands than had been placed before the British public heretofore. These demands were for a 6-hour workday, nationalization of the coal mines, increase of wages, partnership of the employees in the management of the mines, and improvement of housing and living conditions.

The employing coal operators refused all these demands absolutely, stating that any increase in the cost of production would so increase the price of coal as to make it impossible for the English industry to meet foreign competition. The threat and the coal shortage resulting from the strike were of such a serious character as to bring the Premier himself back home from the Paris Peace Conference in an effort to settle the matter.

First Miners' Movement

The first movement of the miners commenced as far back as Jan. 1, when the Miners' Federation of Great Britain adopted their new program, which included demands for a state grant equal to full trade union wages to be paid unemployed miners until work was found for them; the administration of mining conditions by joint district committees of mine owners and workers, and also for the 6-hour day and the nationalization of the mines. On Jan. 7 the Miners' Federation demanded a 30 per cent advance in wages. As there are a million men employed in the coal mines, the acceptance of these demands would have meant an increase of wages amounting to $1,000,000 per day.

On Feb. 13 the Government submitted to the miners its plan for settlement of the strike, formulated by the Premier. This offer included a shilling per day wage advance and a proposal that all the questions should be submitted to a general conference in which the employees should have equal representation with the employers.

The miners absolutely refused this Government offer, but, despite their refusal, the Prime Minister went ahead with his plan and a commission was appointed to make a full inquiry into conditions in the coal industry. Both the investigations of this commission and the strike continued until March 17, when the miners agreed to withhold their strike for a short period, pending a preliminary report of the commission. This preliminary report, when returned, practically conceded all the miners' demands.

The recommendations of the report were agreed to by the Government, and although the investigations of the commission still continue, the entire trend of the investigation is favorable to the miners and it is practically settled that the following conditions will be put in force:

1. **A 7-hour work day (with a 6-hour day after July, 1921).**
2. **Two shillings per day wage increase.**
3. **Voice of the employees in the direction of the mines.**
4. **Either nationalization of the coal mines or unification of same under some joint control of private ownership.**

While the testimony of the employing coal operators and of many manufacturers before the commission was to the effect that, conceding that the miners' demands would so increase the cost of coal as to offer a serious handicap to British industry, particularly in competition with America, nevertheless the condition of the miners was so bad that on humanitarian grounds alone their demands should be in the main conceded.

While, in a way, the result is a victory for labor, yet it is more than that a victory for humanitarian progress and an acknowledgment as to the right of the worker to a higher standard of living. The great coal mine strike was not the result of any new conditions or evidence of any new phase of social unrest. The condition of the coal miners has long been a subject of public sympathy in Great Britain and public opinion had much to do with the final granting of the miners' demand.

One outcome of the investigation was to show that the profits of the mine owners ran from 1 to 2 shillings per ton prior to the war and as high as 4 and 5 shillings during the war.

The action of the Government in relation to the coal strike was based upon three reports submitted by the Coal Industry Commission. One of these, made by the more radical members, recommended allowing of the full claims of the miners. Another of the interim reports dwelt more on the actual statistics of coal mining operations, and the third interim report, called the Sankey report, offered a definite recommendation which the government finally decided to adopt. This report states that the increased wages proposed will mean the distribution of an additional sum of $150,000,000 per annum in wages among the colliery workers.

The interesting part of this report and its adoption by the Government lies in the fact that the commission included eminent men of various shades of opinion, with representatives of the miners and the manufacturers and also public men of a legal and general training. The report is generally referred to as the Sankey report because of the fact that Judge Sankey was the chairman of the commission. The condemnation of the present conditions of the workers in the coal mines is very definite and inclusive in this report.

The Whitley Plan

The national council, which was authorized by the Government to consider the whole question of industrial development, labor conditions and the things which should be done to produce industrial peace, was called in connection with the Government's promotion of the Whitley plan. The Whitley plan has been mentioned a number of times in this country and the general purpose of the plan and its acceptance indicate the recognition by government and by general public opinion in Great Britain of the necessity for equal representation of the workers in control and management of industry, in so far as that control and management concerns matters directly relating to the workers.

This recognition of rights is acknowledged in the acceptance of the Government of the so-called Whitley scheme. The adoption of this plan is the direct result of the unusual conditions existing during the war which compelled the government to require full co-operation between employers and employees, with state authorities, in the control and conduct of industry to permit the securing of the greatest possible plant efficiency and the largest possible production of materials.

National Council of 400 Recommended

The recommendations of the Whitley report submitted to the Government during the war as a plan for future labor policy were put into partial effect, or at least the first step taken, in March of this year, when a National Conference was held, being, in fact, a joint committee meeting of employees and employers similar to that recommended in the Whitley plan. At this conference it was proposed that a National Council of 400 should be formed to be composed of half capital and half labor. It is intended to use this national body as a consultative authority of the government on all industrial matters. Its members are to be elected by the trade unions and by the associations of employers. It is not clear, however, as to whether this proposed National Council is to be joined up with the Works and Districts Committees called for by the Whitley plan.

There appears to be little open opposition to the Whitley plan, as set forth in the report to the Minister of Labor, which he, representing the government, has formally announced will be put into effect. In a way, the

plan is based on participation of employees in the management of each separate industry in a manner similar to the "employees' representation plan" adopted by many industrial concerns in the United States. The plan differs essentially in providing joint district organizations and a joint national council. This plan briefly calls for the following organization:

1. **The establishment for each industry of an organized body, representative of both employers and work people, to be called the Works Committee, to consider and act upon all matters relating to local labor and industrial conditions.**
2. **The formation of District Councils representative of the trade unions and of the employers' association in each industry.**
3. **The formation of Joint Standing Industrial Councils to be equally representative of the employers and of such industries as are not already represented by trade union organizations, the purpose of this being to secure a representation for the masses of unskilled labor not included in the regular union organizations.**

It is the purpose of the plan to have the Works Committee and District Councils act upon matters of a local nature which can be decided by them, including the conditions of employment, the methods of fixing, paying and adjustment of wages, and the establishment of regular methods of negotiations for differences arising between employers and work people and means for preventing unemployment.

It is intended that the National Council should only take up matters of general or national importance, such as legislation, state control, etc.

The difficulty of succeeding with a general employer-employee co-operative plan with the unskilled workers, not included in the regularly organized trade unions, is fully recognized by labor leaders and industrial economists and the subject is quite fully covered in a recent "second" report of the Committee on Industrial Relations of Great Britain which originally outlined the so-called Whitley plan.

Report Does Not Favor Compulsory Arbitration

This committee recommends that the existing Trade Boards Act, enacted because of the needs of the war, shall be continued. The original purpose of this act was to provide means for establishing a minimum standard of wages, but in addition to such purpose, it is now proposed to use this medium for the organization of "Industrial Councils" for unorganized industries.

It is noteworthy that this second report of the Industrial Relations Committee does not favor compulsory arbitration, stating that both employers and employees are opposed and that imposition of forced arbitration would lead to further unrest. Neither does this committee favor compulsory methods to prevent strikes, pending negotiations.

In promoting the Whitley scheme, the government does not intend to abandon for the present the other existing government agencies provided for industrial reconstruction and for promoting better industrial relations. One idea is to link up the National Industrial Council, to be organized under the Whitley plan, with the work of the present Trade Boards and other joint representative industrial organizations organized during the war. The government is also maintaining trade union advisory committees at the headquarters of the government departments, as well as local labor advisory committees in various localities.

It is noteworthy that the Department of Labor continues to use its Trade Board organization for the adjustment of conditions relating to the employment of unskilled labor not organized by any of the established unions. Only as recently as February, the government took action regarding wages in the trades devoted to the manufacture of garments, knitted articles, embroidery and various needle trades, which have no representative unions.

While the Whitley plan was worked out by a committee representative of both employer and employee interests, and while there is no open opposition to the plan expressed by the union workers, yet there has been some evidence of suspicion on the part of union labor interests against the idea of works committees. Doubtless this position is based on ideas which prevailed to some extent in the United States, that by the building up of works committee or employees' representatives, to deal with the employers in conference, the result will be to weaken the strength and importance of the local trade unions.

"Triple Alliance" Stands Aloof

Although the National Industrial Conference continues to function and at its meetings subjects of the greatest importance to labor are considered, even such questions as giving to workers a direct share in the control of industry, yet it is notable that the "Triple Alliance," the most powerful of all trade union combinations, stands aloof from this government effort to solve the industrial problem by co-operation and conferences. No delegates or representatives of this union organization officially took part in the proceedings of the recent National Industrial Conference.

Leaders of this union organization do not admit that they are opposed to the National Conference or the Whitley plan or that they will refuse to enter into them, excusing themselves on the ground that other important affairs have prevented them from participating. It is not certain that this large trade union element will eventually co-operate in the National Conference or the Whitley plan. The Whitley plan is supported strongly by the National Labor Party leaders and is part of the policy of the present government administration headed by Lloyd George.

Great Britain's Relation to Labor

The important position which the government of Great Britain holds in relation to all labor and industrial questions is shown by the history of recent events. The great coal strike would have resulted in serious disaster to British industry if Premier Lloyd George had failed to secure a compromise agreement.

The government is working hand in hand with the organized trade unions, and that it recognizes the trade union power fully is evidenced by the refusal of the government to intervene in any way in the recent strikes on the Clyde and elsewhere, basing its opposition on the wishes of the trade union executives. In the case of Glasgow, although the Lord Provost asked for intervention by the government, the administration officials refused, stating that such action would undermine the authority of the national trade union representatives.

Although the Whitley plan of the government is not yet fully in operation it has been applied in several of the separate industries, notably in the manufacture of pottery, rubber and watches. These have a full system of shop committees, district councils and national councils organized and operating.

These developments indicate the extent to which the labor situation in Great Britain has become a political matter and the extent to which the labor organizations can enforce the political consideration of their demands. They illustrate the extent to which the Government has recognized the necessity for change in the general organization of industry in order to preserve harmony and to insure a reasonable, peaceful development.

It is not possible, as yet, to determine the ultimate success of the Whitley plan, or the other methods of governmental consideration of the labor situation, because labor opinion itself is divided as to the improvements to be secured and the methods to be adopted in securing those improvements. Probably 65 per cent or 70 per cent of the workers would be very glad to return to pre-war conditions if pre-war prices could be returned.

Leaders Recognize Value of Slow Development

The older and more experienced leaders in the labor ranks see the necessity for slow and careful methods of development, and even the aims of the labor political party itself, as shown by their reconstruction platform and the statements of the party leaders, specifically indicate that there is no expectation of accomplishing these things in any short time; and that the main object before the party is to see that each development builds toward the final platform which they propose to support. The great danger in the situation arises from the division of opinion within the ranks of the labor organizations as such, both as to the aims which can be immediately fought for and the methods which can be used in endeavoring to secure them.

The growth of the shop steward system in Great Britain has had a very distinct tendency to remove the power from the leaders of the national unions, or at least to take away a sufficient amount of that power to make it difficult for such leaders to control the whole body of workers under any agreement. This is evidenced by the history of the strikes which occurred between the signing of the armistice and the present time.

Strikes Reaction from Wartime Production

Unquestionably, a number of these strikes were made possible because of the general reaction from the war production necessities, the restrictions imposed during the war, and the strain which the country suffered for several years during that period. These strikes were called for demands which varied considerably. They were sufficiently widespread to indicate a spirit of general unrest, but more particularly they were based upon the local demands of the workers in some part of the country led by the District Allied Trades Council, which is the shop stewards body. They were frequently called in direct opposition to the national organization, of which the strikers were members and conducted without the approval of such organization.

In a number of cases the union leaders made common cause with the Government, and it is interesting to note that the strength of the labor organizations, in their power over their own ranks, was still sufficient to enable the employers to refuse any dealings with their own employees except through the recognized union leaders. The shipbuilding strikes, which were particularly bad in Belfast, where they developed almost along the lines of a completely socialistic government, were broken because of the division in the labor ranks and the regular union organizations were greatly strengthened by the defeat of this movement.

The great strike of the Triple Alliance, which is a cooperative organization of the three great industrial unions, railway workers, miners, and the transport workers, was one of the most difficult to settle, and it is not certain even now that this matter has been sufficiently settled to eliminate the possibility of further strikes in the near future.

Strikes have crept into the cotton district in Lancaster, in the engineering and shipbuilding trades, in the electrical trades, all of which strikes finally collapsed without any material change in the situation except agreement to reduce the hours to 47. Almost all the strikes were unofficial strikes. They were conducted by the local shop stewards, and were not recognized by the older leaders. Their breaking down is evidence that the radical element, which favors the direct action through the shop-steward system, is not yet sufficiently strong to endanger the recognized union organizations, although the number of men who became involved in the strikes indicates that there is a very large movement among the labor bodies to demand clearer and more direct action in connection with their local disputes than is provided through the regular organization.

This is partly due, of course, to the reaction from the war and partly due to the growth of radical opinion in the ranks of labor, which threatens to disrupt the labor organizations themselves.

Industrial Unions

A feature of this radical development, which has grown out of the formation of the shop-steward movement within the Allied Districts Trades Council, has been the movement in favor of industrial unions instead of occupational unions which form the machinery of the recognized labor organizations. This development arises more out of the political labor party and its growth than it does out of the actual union organization; but the ability of the Allied District Trades Council to enforce its demands, where the old craft unions have been unable to enforce them, has developed a strong opinion in the labor ranks in some cities in favor of industrial unions all through.

This has attracted to its side a number of social reformers and a considerable body of opinion which lies outside the labor ranks, but which is affiliated with the labor party as a political organization. So far, the tendency toward industrial unionism is not of importance in Great Britain, and it is not likely to become so if the tendency of the present developments continues. It is probable that further economic troubles of a more or less serious character will occur in Great Britain, due to the conflict between the industrial unionism as represented by the shop-steward system and the craft unionism as represented by the older organizations, and that the radical element will find sufficient following to induce them to make excessive demands and attempt to enforce these.

There is no indication, however, that these movements will assume sufficient importance to materially affect the developments which are taking place or to interfere with the orderly progress which is being made in the settlement of these important questions.

In all the actions which have occurred in meeting the strikes in Great Britain since the armistice, in all discussions of the labor questions in the triangular conference between government, capital and labor, there has been a distinct and definite tendency toward shorter hours and work. In connection with this matter, of course, it must be remembered that in Great Britain the hours of work have been longer in the past than those usually obtaining in this country, and the historical background suggests an importance in connection with this demand which it does not possess in the United States.

The 48-hour week is practically admitted in all types of industry to-day in Great Britain. In the case of the shipbuilding trades strikes, engineering trades strikes in Belfast, Glasgow, and other points in the British Isles, the demands for working hours range all the way from a 47-hour week to a 30-hour week. The decisions were made upon a 47-hour week in London. While the same organization in Belfast was demanding 44 hours there was a strike in Glasgow for a 40-hour week. Most of these strikes were unofficial, and the engineers' and shipbuilders' strikes were first broken by the decision of the Liverpool Federation to continue work.

The Liverpool Federation stood 10,000 in favor of 44 hours and 8000 in favor of a 40-hour week. These strikes failed, but the 47-hour week was adopted and it is probable that further development will necessitate a reconsideration of this and the elimination of three hours, making it a 44-hour week. In the report of the commission appointed to deal with the coal mining industry the recommendation, on account of the peculiar conditions in this industry, starts with a seven-hour day until July, 1921, after which time a six-hour day shall be considered.

At the last annual meeting of the Lever Bros., Ltd., of Port Sunlight, near Liverpool, the directors of this company reported that they had adopted a 36-hour week.

In practically all of the strikes there has been a tendency to reduction of hours, and the demands of the unions lie about half way between the 48-hour week and the 40-hour week. In some few cases local organizations have demanded smaller working days than that, but there is a very large opinion, as indicated by the votes and the actions of the different unions in the trades, for a week ranging between 40 and 47, with a majority of the workers in favor of a 44-hour week.

If the votes and strikes of the scheduled trades involved indicate anything in respect of the future probability, they suggest a very definite, powerful demand in the organized unions of Great Britain for a shortening of the traditional hours of labor and it does not look as though the present 48-hour week would last very long without further attempts to reduce it.

Up to the present there has not been any great tendency toward wage reduction in any of the large industries, although in some of the smaller branches of trades there have been reductions. In fact, in some of the large industries, particularly in the railroads, which are under government control, and the cotton and engineering trades, there were demands for increased pay. In the settlement of the railroad strike there was a considerable increase allowed the workers. In the settlement of the cotton strike, which occurred just after the armistice, because the cotton mill owners repudiated their promise for increase made during the war, a 50 per cent increase was decided upon with an arbitration settlement to finally determine the matter. The coal miners were allowed a 30 per cent increase.

These advances are evidence that there is no tendency for wages to come down, although the unemployment continues at a very high rate.

Reports from Great Britain show unemployment in the United Kingdom on April 14 of a total of 246 unemployed per 10,000, and about one million pounds per week was being paid out as unemployment wage. The unemployment as reported at the beginning of May was slightly less and the last reports indicate a very slight decrease. It is evident from the conditions in the very important industries in Great Britain that the question of readjustment is a very difficult one and that it will be some time before the unemployment rate decreases to a reasonable percentage.

Unemployment Insurance

The obligations of the government for unemployment insurance must continue to be high for a considerable time and will probably amount to about two hundred million dollars this year. The extent to which factories were increased in Great Britain for war purposes has not been understood in this country, and it can hardly be measured without a knowledge of the preceding circumstances. The conversion of Gretna Green, which before the war was a village of one street and probably 30 or 40 houses, into a city with ammunition plants aggregating approximately 9 miles long by 3 miles wide, with the necessary housing and other accompaniments, is a little indication of the way in which manufacturing facilities grew during the war. The difficulties entailed in turning these facilities over to peaceful occupations so as to maintain the employment which was built up during that period.

The demobilization of the soldiers has not occurred in Great Britain at the rate at which it is proceeding in this country, and this has kept down the unemployment to some extent; but it is to be expected that there will be a great deal of unemployment in Great Britain for some time to come on account of the enormous difficulties in the way of adjusting all manufacturing facilities to the necessities of peaceful work and reviving the trade which was lost in the concentration upon the war requirements.

One of the demands made by the labor party in connection with its reconstruction platform was the demand for better housing. This has been a subject of political controversy for many years in Great Britain and there is no question but what the housing conditions in many parts of the country were poor before the war and these housing conditions were not improved with the consolidation of manufacturing demanded by the war necessities.

Millions to Be Expended for Homes

In the United States we have some housing problems, but we have no such problems as those confronting the people in Great Britain, where their population has been shifted to a very much greater degree and where the percentage of men going into service was so much higher a proportion of the population. The development in building is going ahead in a good many districts at the present time, and it is expected that millions of pounds will be expended by the government and the local government bodies for the erection of workingmen's houses throughout England, Scotland and Wales.

It is not expected by any of the parties, or by any section of public opinion, that the housing problem can be settled through private means, and it is probable that the government will be obliged to assist in this program for a number of years in order to introduce the conditions which should prevail. It is not only that the number of houses required are not available, but the character of the houses for workers in Great Britain is inferior to those in the United States, and the facilities for sanitation, etc., are not nearly so complete. Bills have been introduced in the House of Parliament offering various solutions. The programs are not finally settled, but it is probable that the government will aid in the financing of local housing operations.

At present the government is financially helping the public utilities associations for the building of houses, and some of the local trade union organizations are contemplating qualifying themselves, legally, to act as building associations to enable them to secure this government financial aid. Our reports on the resumption of building activities in Great Britain indicate that in several of the districts this resumption shows an increase of 300 per cent or 400 per cent in the last two months.

War Has Helped Define Aims of Labor Party

The general situation in Great Britain shows that the war has developed a definition of the aims of the labor party as a political party and the labor organization as a craft union which consolidates the demands of labor to a much greater degree than was visible before the war. The aims of the labor party are summed up effectively in the platform for reconstruction which has been closely adhered to in the later speeches of the labor party leaders. This platform is very radical in many of its ideas and would be called a socialistic platform in many respects.

It should be noted, however, that the labor party in speaking of workers includes all workers, brain and hand workers, in the term workers, and in this respect its definition is entirely different from those of the craft unions. The definition it makes between labor and capital is the definition of those whose toil enriches the community and those who make no production effort.

The consolidation of these demands in the political aspect of the labor question, as well as the definition of the demands of the draft unions, has resulted in the general admission of some points which are still in controversy in many other countries.

Public opinion in Great Britain, including the opinion of employers, acknowledges the right of the worker to representation in the management, at least in respect of the things which concern his working surroundings and employment. The general statements by important manufacturers, by prominent public men of all types and by those whose words would count in Great Britain, indicate that the employers themselves and the general public recognize the obligation of industry and society to provide the worker with certain stable conditions of living and with certain opportunities for development, as well as a measure of partnership in the decision of the governing principles under which matters shall be arranged.

During the past six months a group of employers representing the principal plants in one of the most important British industries met in London and prepared a set of guiding principles relating to the management of their business, which outlined their duties as regards wages, the place of the worker in the management, security of employment, disposition of the profits and other subjects.

In the matter of wages, their conclusion was:

"These should always be sufficient to enable a man to marry, live in a decent house, provide means for the upkeep of the physical efficiency of the family with a margin for contingencies and recreation."

This declaration was in effect in favor of the naming of a minimum wage based on a cost of living. Continuing, the declaration of principles says:

"The worker asks to-day for more than an improvement in his economic conditions. We admit the justice of this claim and we must co-operate with him and treat him as we should wish to be treated ourselves. We propose to create suitable machinery for this purpose but believe that the more essential thing is the living desire to give full expression in a belief in right relations. Experience on shop or works committees trains the members in participation. We shall promote the formation of such committees."

It is this admission of the points of agreement between the public, capital and labor which gives rise to the hope that the adjustment of the situation in Great Britain will be made with orderly development, although it cannot be made without some economic disturbances. Unless the radical element in the older organizations becomes much stronger than it is, the control of the situation by the craft unions and the statement of the leaders of the older organizations "that progress must be made a little at a time" indicate the general feeling that there is sufficient groundwork of common opinion upon the necessary developments to provide progress which will be satisfactory.

Peace Will Offset Radical Demands

The conclusion of peace and the concentration of governmental activities upon domestic political issues will hasten the orderly development and offset the radical demands that have a tendency to accumulate during times of unemployment and industrial depression.

It is clear, however, that in Great Britain the position of capital, worker and government will be determined from a viewpoint which we would consider more radical than anything at present on the horizon in this country and the conclusions arrived at will tend to admittance of principles which we are not prepared to admit as axiomatic in the United States.

There is no doubt that Great Britain of pre-war days as a political government, has gone and that the labor party power will be felt in all the political developments of the next few years. The radical opinion may force political consideration of matters which should not be considered from that standpoint, and for a time labor power, forced by the radical demand in its own ranks, may go beyond wise development.

There is some tendency of this kind to be observed, but it is admitted that the position of the worker, politically and industrially, has been entirely changed and that it is necessary that recognition be given to him in a different way, so far as Great Britain is concerned.

NEXT WEEK Mr. Tipper will discuss the developments in labor conditions in the United States since the signing of the armistice. This will be a comprehensive study of the situation, especially applicable to the automotive field and will be a document of great importance to every employer of labor. The development of the labor organization situation and the attitude of employers are traced through this period of surprises.

The Experimental Car

An Outline of the Methods Used in Developing New Models for Quantity Production—Experimental Department Organization and Routine

By C. Roy Watson

TO make automobiles that sell like hot cakes on their inherent merits is no chance nor haphazard business. Every firm desires to have its product held in high esteem by the buying public and to enjoy the privilege of selling cars when the mediocre firms are feeling slow times.

Granted a good manufacturing organization, all that remains to make a success is a well developed car, and that means good engineering, checked by able experimental testing. The writer's purpose in this paper is to give the methods of experimental car testing developed in several years of his experience with a leading manufacturer. Like most things in these days of highly detailed design and efficiency, a great deal of method or system has to be used in the experimental work to get good results. I am not going into the planning nor designing phases of engineering work, except as it borders on the experimental.

How Not to Do It

Many automobile makers to-day do not fully realize the importance of thoroughness and high standards in the experimental work. The usual procedure when a new model is brought out is to build a single experimental car composed of the first guesses of the engineers. The motor is perhaps given some kind of a block test and the car goes to the road where it is driven irregularly by an ordinary tester, and on week ends by more or less biased and theoretical engineers. Replacements and new devices are put on from time to time and the developments disturbed by tightening ups and "babying." Time on the road is wasted in making advance demonstrations to dealers and trifling in general. The result is that little progress is actually made in developing the model, and that when the cars go into production a ferocious scramble ensues to patch last hour discoveries, loose odds and ends and unforeseen manufacturing difficulties. This means expensive delay in production, an increased scrap pile, profit killing replacements and negative advertising by consumers.

Method or System

The time necessary to develop a new model to the point of production varies according to the amount of newly designed detail. An old model that has successfully stood the acid test in the public's hands, on which there have been made a few minor detail refinements, requires little time, although a standard of, say, 30,000 miles of methodical road testing is always a good precaution. Such a test represents an average of five years' use in the average owner's hands. Naturally, hot and cold weather, wet and dusty roads, etc., should be covered by the test in order that it may be thorough.

In the case of an entirely new design the drawings must have been completed and the commercial arrangements for stock assured. The experimental car parts must then be built and prepared and the component units pass through the laboratory tests, leaving a period of from four to six months' time for tests of the complete car on the road. If extremely radical designs are to be incorporated in the model, much more time has to be given to the doubtful features, as many an engineering organization has had to make a right-about face with some features that could not be made practical in time.

After the experimental cars have developed all the bugs and the machine is a success, the manufacture of parts for the new model should be sandwiched between the production of the current model, and the development of tools, material specifications and the shop organization of means and method be completed. In this way the new product can be smoothly dove-tailed into the end of the old season's product and the common losses and delays in starting the new season avoided.

In order to run the whole gamut of service that the motor public will expect the car to stand up to creditably, and to systematically handle the complex details of development, three experimental cars had best be built. With one car alone all the eggs would be in one basket, and in case of a road or shop accident all the work done might be lost. In the section on the system of testing out it will be seen why the third car is advisable.

Outline of the Work

The experimental staff should be a highly trained and talented force, with such equipment as is necessary to do the work efficiently. They should work in an atmosphere favorable to keen observation and originality. With a live firm it seems that there is ten times as much work to do as the Experimental Department can handle. In the automobile business resting on the oars is permissible only to the few firms who are greatly in the lead. Some have taken a hard back slide due to relaxing the aggressive policy. A leader must work hard to retain his position. I will outline the experimental work advisable to all firms in a season's program:

A—Developing the new model.
- 1—Building the experimental car and parts.
- 2—Laboratory tests and developments.
- 3—Road tests and developments.
- 4—Acceptance and commercial co-operation.

B—Super-testing the factory product.
- 1—Acting upon agents' complaints and suggestions.
- 2—Experiments on employees' cars.
- 3—Replacements under commercial exigencies.

C—Research.
- 1—New designs and accessories submitted.
- 2—Commercial material substitution.
- 3—Competitors' car study.

Super-Testing the Factory Product

From the outline it would seem that there is a good deal to do after the car is put into production. When the factory starts to build the car a certain amount of co-

operation is needed from the experimental force to straighten out difficulties in manufacturing and to closely inspect the new production to see that it is fully up to the highest standards of quality. One of the first cars of the production should be taken out by the experimental testers and driven 10,000 miles under all conditions to be sure that all is going well with the new product. The factory test is generally a short affair and only serves to show the most superficial defects. In the "super factory test" defects in workmanship, materials, heat treatments, accessories, etc., are found without waiting for the agents to get a number of cars into the public's hands and in time figure the trouble out and then give the alarm. This test always saves many times over what it costs, and should be repeated two or three times during the season. These cars, with the other experimental cars, can be taken into the shop, standardized and refinished somewhat and sold at cost to the employees, who will eagerly bid for them. In selling such cars a resale limit can be imposed reasonably and perhaps some minor experimenting carried on, on condition that the owner supplies the experimental department with his views and findings. There is nothing like getting an expert to personally get the tools in his hands and minister to perhaps some of his own deficient contributions in the model. He soon sees the point or helps chafe the guilty parties.

Refinement and Substitution

During the season the agents and others make criticisms or suggestions for minor refinements. With judgment, these minor changes can be thrashed out on any car under test, where they will not interfere with more essential things. In the case of the failure of supply during the season, of any material or part, due to some commercial reason, experiments can likewise be made for substitution.

Research

Innovations come along from time to time for study and development. These are the things that add selling attractiveness to the product or cut manufacturing cost. They have to be sandwiched into the current experimental work, or, if important enough, a car may be provided specially for them. As a rule, an intricate device should be installed by the parties submitting the same, and with prudence a certain amount of collaboration can sometimes be permitted. Often only the germ of an idea is brought in and nine-tenths of the adaptation and development has to be done by the car maker to get the device into practical form.

Study of Competitors' Cars

Some makers study competitors' cars and get many ideas, both of operation and construction. Like the foregoing work, this is best done by the trained talent and the comment of various experts of various viewpoints. The engineers should first look the car over in turn and drive it on week ends and evenings, then have a clever tester measure the performance in every way, run up the mileage for developments, disassemble for inspection and then have an expert draw up an analytical comparison to facilitate the study.

Equipment

A set of rooms, or, better, an efficiently arranged building, should be provided exclusively for the experimental work. A good arrangement is to have one large and one small door near together. A guard must be posted at the doors and the place not allowed to become a curiosity shop for prying individuals. People on business should be received by the guard in an ante-room which is surrounded by the necessary offices. Following in order grouped around a common stock room should be the machine shop, laboratory, and garage with large communications and doors. The shop and garage should have partitions or small rooms on the side for special work, and the laboratory should have a muffled wall testing block; a special corner can be used for dead stock. The machine shop should contain mainly tool maker's machinery, and the size should depend on the quantity of work it is expedient to do in the factory, in keeping with the required degree of secrecy. The laboratory contains motor testing equipment and apparatus of all kinds to make quantitative and chemical tests. The garage contains plenty of parking space, facilities for building, filling, cleaning and repairing cars, etc. The location of this department should be such as to be hidden from public and factory view and it should contain the usual conveniences for the men so as to keep them within their own sphere.

Personnel

The men doing experimental work must be trained experts in their specialties and not ordinary mechanics and drivers. They must be deeply experienced, practical, critical, and ingenious. Ordinary wrench slinging dubs have no place in the work except to demonstrate perhaps at a later stage how the car may be abused by careless owners and poor garage talent. The organization of the staff is as follows:

The experimental engineer in charge has a general routine supervision over the whole work, sits in the conference of engineers and must be able to keep a smooth, alert frame of mind among his assistants, some of whom might be of more vital value in the work than himself. Three foremen of the machine shop, laboratory and garage look after their respective divisions and make reports in writing and suggestions directly to the forum of engineers. Lastly, the chief experimental tester is like the home guard in a football game—the last man to stop bad design and mistakes. He must be very thorough.

All must work in a friendly, unbiased, and critical atmosphere and be encouraged to churn up data and ideas without any fear or favor. All should be assured that they are under the direct protection of the head of the company and should be cautioned to secrecy outside the department.

Constructing the Experimental Cars

It is necessary at times to get special work done in the factory on the highly specialized production machinery. In fact, it is desirable that it should be done for training as far as is consistent with workmanship, expediency and secrecy. The latter factor need not be much worried about ordinarily, at least not in the case of conventional designs and where the volume of such work obscures the identity. A general policy throughout the conduct of the work, of not allowing doubtful characters to get more of the plan than is helpful in their detail of the work, serves to keep them from getting all the links in the chain and having enough to do any harm.

In the process of making the experimental parts—and in assembling them together, expert study must be given to every detail in order that data may be secured at every stage of the work for checking developments in the tests, that they will be identical in material, heat treatment, limits, etc., to what they will be in the manufactured product, that conflicts and inaccessibilities are eliminated and that manufacturing facility is incor-

porated. Every piece should be analyzed for material, and heat treatment where important, in order to insure that everything is up to specification and that no parts materially weaker or stronger or more or less durable than the normal get in to ruin the conclusions at a later stage of the testing-out work. Likewise, the parts should be carefully checked for alignment, dimensions, finish, etc., and in some cases both extremes of the limits provided for trial in parallel tests. Axial lines, bench and description marks should be inscribed on all new and doubtful parts and assemblies, in order to later study any bending, twisting or undue wear that may occur.

The careful stamping of parts not standard should be looked to, and anything needing special identification should be stamped where the mark is most visible at all times. Parts with rough and indefinite limits should be carefully measured, and data kept in a tabulated diagram. Likewise, diagrams of dimensions should be kept of all parts that wear. A ten thousandth part of an inch in such data is a good limit of measurement. There is nothing more exasperating than to get a break, bend, twist, reduction or wear effect and not have reliable data to go back to in drawing a conclusion. Workmanship in experimental work is a bugbear, and too much cannot be said on the subject. Neglect in this matter wastes time and money.

The valuable detail judgment and co-operation of manufacturing specialists will add value to the work, provided it is diligently collected and tactfully handled. Remember these things mean savings in money, and the car is composed of almost millions of little details. This is a little sermon on the way.

A skeleton chassis, such as some firms employ in testing out, is only a small part of the car. It is a waste of time to stop here. The scientist's assertion that every atom in the universe has a relation to and an effect on every other atom applies especially strongly here. All the superimposed and attached parts and the equipment have their mutual fits, their co-operative functions, their clearance relations, their stiffening and weakening influences, their weight effects and must be in position when making the test. The complete car should go to the road fully equipped with no ifs or ands.

The body, top, curtains, shields, fenders, control mechanism, piping, wiring, etc., are portions generally designed by different hands, and the complex locations in different planes make many things a matter of individual fitting and adaptation, and templates must be made and allowances fixed early. Often very embarrassing and ridiculous conflicts are found in the finishing up stage where the work is improvidently conducted. The sooner such defects are found and eliminated the better, as elaborate body and sheet metal dies and forging tools take long periods to alter.

Laboratory Tests

Many of the parts, accessories and sub-assemblies need laboratory testing before going together. This is a very important work, and volumes can be written on the equipment and procedure necessary to do this basic work thoroughly. Things are in general more accessible in the laboratory than on the car.

The complete car on the road should be regarded as the final elimination test or the last checking out of things overlooked and unforeseen. Every defect found is something of a debit mark on the thoroughness of all concerned in preparing the experimental car. The more closely the laboratory can calculate and judge to road performance the more effectively their work will be done.

The standards of efficiency in laboratory work are rising fast. Things are more accessible for fine detail study in the laboratory than in the car. With the tendency toward light weight construction, cleverly arranged physical tests eliminate the clumsy method of risking the tester's life in the road test. Material and heat treatment inspections are conducted here. The motor is tested here for internal friction, power, flexibility, lubrication, balance, cooling, ignition and carburetion and its shortcomings are eliminated. The clutch and transmission are tested for inertia effects, holding, slipping, shifting, lubrication, etc. The rear axle and universal joints are tested for lubrication, heating, etc. Accessories like tire pumps, horns, speedometers, fuel feeders, primers, etc., are also gone through in a suitable way. When the car is completed the spring action is studied by weighting and jacking up and down, and interferences are studied. The limitations of the bumpers and rebound straps are noted and the arcs of axle movement all compared to the angles and sliding of universal joints, brake rods, torque bars, etc. Many incalculable and unforeseen details operating through several planes like control rods, under pans, and accessory connections, etc., must be corrected here. Weighting of the parts and sub-assemblies should be done also for comparison and future reform at least. Tabulated measurements of the operation of sylphons, metering and control mechanism, spring travel, etc., must be taken for future reference.

Testing on the Road

At least two experimental cars should be provided for the testing of each new model, no matter how few new features are brought out, as it would be an exceptional new model that did not contain at least a number of refinements in details. Ordinarily three cars had best be built, and two of them driven on the road by experienced professional experimental testers who are equipped in their specialty to adequately put the cars under every possible service and abuse the owners will likely give them; to report defects intelligently, and to suggest remedies and improvements from their intimate viewpoint.

The first car can be driven continuously, or twenty-four hours per day, by two or three shifts of two men each. During the pre-production period some of the drivers can be commercial testers studying the new model and getting prepared for testing it. The purpose of the two men on each shift is to expedite any work done on the car on the road, to divide up the driving work, help in heavy road difficulties, expedite caretaking work and that one may serve as a rescuer if he escapes injury in case of an accident. It is needless to say that poor or careless drivers will not be a good investment in experimental work. One of the two drivers in each shift serves as the captain of his shift and makes reports directly to the chief experimental tester, keeps up the data collected during his shift and opportunely co-operates with the engineering and experimental forces.

One of the results gained on the 24-hour car will be the effect of great distance, as 30,000 miles can be turned up normally in three months; another will be plenty of abuse administered, as the men get on a fine driving edge and can "slam her over the road" in good shape. Figuring an average driving season as 6,000 miles, the distance traveled will represent five years of service and the maximum of road abuse the car can receive. A car tested to this degree and found "all there," can hardly be compared to the one and two-season repairshop wrecks which are due to the low engineering standards of the makers.

At this stage the car should be completely taken down and inspected. It should have gone through the test without adjustments of motor bearings, cleaning of carbon, valve grinding, replacements and adjustments, and still be in fairly good running shape. With a few slight adjustments and cheap replacements, *i.e.*, a light overhauling, it should give a creditable performance and be ready for another long period of use.

The result of frequent warming and cooling, cold, garages, slow and irregular driving resulting possibly in rust, condensation, corrosion, freezing and the fine detail study cannot be got on the 24-hour or big mileage car, so the second car should be driven by a crew of two during the usual day of work and at times a little in the evenings. The sharpest talent should observe this car, and it should be tested all around the country and subjected to all possible conditions.

The third car should be kept about the shop to use for a model in fitting and measuring, etc., without holding up the active cars for that time-consuming work. This can be loaned to the engineers for their driving and study and also possibly used at times for some advance demonstrations to dealers. Side issues should not be allowed to conflict with experimental work. Using the experimental cars for personal and commercial services should not be tolerated. These things always consume more time than anticipated, distract from the work, destroy observation and spontaneous thought and interfere with road and weather opportunities. Routine matters should not be allowed to intrude on the work at any stage, as they spoil keenness of thought and originality.

After the rawest defects have been eliminated and the cars found safe to go out of the vicinity of the shops, every kind of roads and climate should be visited. The extremes of hot and cold weather should be experienced to see if the carbureting, cooling and other temperature-affected factors are right. Winter work in the north can be supplemented with warm weather driving in the south. Sand, gravel, dust, mud and snow roads should be sought to see if any kind of dirt gets in anywhere and does damage by clogging, chemical action or wear. To see if the clearances are good, the pulling is smooth, the brakes are adequate and all suspension, torque and running gear parts strong under abuse. Mountainous roads, rough and smooth roads, wet and dry roads should all be tried out in various combinations. A volume could be written on the fine details and abuses and the money that motor car companies have lost by lack of thoroughness in their testing-out work.

The Car's Initial Run

When the new car is first started out it should be run easily, well lubricated, and kept in good adjustment for a little while; then the severity of the work should be gradually increased in every way to a reasonable point, and finally the maximum of reasonable abuse and overload should be given. In this way the whole story of the weak features is obtained, whereas if the model was roughly handled from the start, and smashed, only one thing would be learned, and that is that it would not stand the maximum. As an abstract deductive method of analysis of the qualities of a car the practical maximum and minimum of everything must be considered. Two qualifying conditions creep in here: One is practical experimental judgment based on broad knowledge and experience and the ideal of the "Old One Horse Chaise" mechanical principle. Not that the climax in this ideal is looked for exactly, but that the standards in lubrication, adjusting, repairing, or the caretaking requirements are not such that a little neglect on the motorist's part is going to result in stalling him in the middle of a California desert or call on him to buy half of his car over again. For instance, if a ball or roller bearing is used in a part of the car likely to be neglected in some way, the chances of trouble to the motorist (which is always trouble to the manufacturer as well) will be much less perhaps than with a plain bearing that might seize and twist off a shaft, rip up a set of gears, or smash up a big casting. Such deep considerations make the fine automobile that connoisseurs speak of with admiration. The lack stamps the improvidential institutions that can hardly get their product to the shipping dock and be sure that something is not going to happen the next minute.

After the crudest of weak points have been remedied, the experimental work simmers down to the long-distance, long-time durability tests and the fine detail study under various climatic and road conditions and the unforeseen combinations of circumstances that are stumbled onto by accident.

About every 15,000 miles the car should be taken down and inspected thoroughly. When doing work upon parts that have fallen down in the test everything opened to view should be inspected, but it should always be kept in mind that frequent adjustments, tightening ups and minute attentions such as the average owner neglects should not be made, as valuable developments are apt to be lost. If the car is going to be a rattle trap, keeping the experimental and demonstrating cars tight is not going to help the motoring public's opinion in the least. It is better to find these things out at the factory and remedy them than to wait for the public to advertise the outfit as a junk pile.

Paper Work

An important aid in the work is the compiling of data and reports. These things are indispensable. On the cars, log books are kept of fuel, oil, water and tire consumption. Odometer readings, gage readings, acceleration readings, climatic and road conditions, are kept, tabulated for reference and comparison. Likewise, impressions of speed, power, noise and vibration are recorded. Thorough reports of the experimental work and data collected, as well as remedies and suggestions, must be promptly prepared and sent to the engineers and those helpfully concerned in the work. The reports are typewritten on a form handy for filing, and their delivery is carefully checked. An index is kept, which is compiled from the reports and data, and is available to all. The system compiles the story from the standpoint of problems under development, sub-assemblies and functions in the car. In this way the history of any development can be found quickly and without searching through a mountain of papers for little details. Insufficiently checked details and guesses should not be sent in unless time presses, and then they should be labeled as such.

In all experimental work the keynote must be thoroughness and adherence to actual operating results, and not pure deduction and theory. Some engineers are like the woman who dropped four cents on the street car floor and left the conductor to look for five. An engineer with a salesman's graces is a danger to the community. The work is impersonal. The experimental men must consider themselves as the company's and the purchasers' friend jointly, and not allow anything to be "put over" that is not up to the highest standards of the art. It is the duty of the management to see that the critics are not molested in any way by offended persons. Politics in the shop and underground bickerings caused by a neglect of the management to thoroughly supervise are very demoralizing to results in engineering work.

Truck Loading Devices Reduce Lost Time

Installation of Apparatus for Handling Loose or Bulky Material Cuts Labor and Increases Profits

By J. Edward Schipper

WHEREVER quantities of loose materials, or materials of tremendous bulk, have to be loaded into trucks the problem arises how this can be done so that the loading time and the expense of loading will be reduced to a minimum.

Every time an analysis is made of truck transportation cost, the length of time required for loading is found to be an important factor. Therefore, truck manufacturers, contractors and fleet owners are constantly endeavoring to cut down the time required to load or unload the vehicle and are giving every encouragement to the design and invention of devices which make this possible.

Loose material such as dirt, gravel, coal, ashes, etc., is most difficult to deal with. Solids, such as stone, bales of hay, bales of cotton, furniture, crates, etc., do not present as hard a problem, because they can be lifted on the loading platform and generally packed very easily by the driver and helper into the desired position. Where the articles handled are of miscellaneous size and shape, as in moving van service, manual labor has to be depended upon entirely, and for this reason a different basis of charge is generally used in this class of work. For handling the loose materials mentioned, however, a variety of devices are in use, and many of these are of exceptional value.

Dumping is the most common method of unloading loose material. Dumping bodies were employed to a considerable extent on horse-drawn vehicles before the motor truck came into common use. These early dumping bodies generally were manipulated by the driver, who inserted a crank on the squared end of the shaft and cranked the wagon body up to a dumping position. A train of gears gave the reduction necessary to enable one man to readily lift a loaded 2 or 3-ton wagon. This type of body was extensively employed for retail delivery of coal and is still in common use.

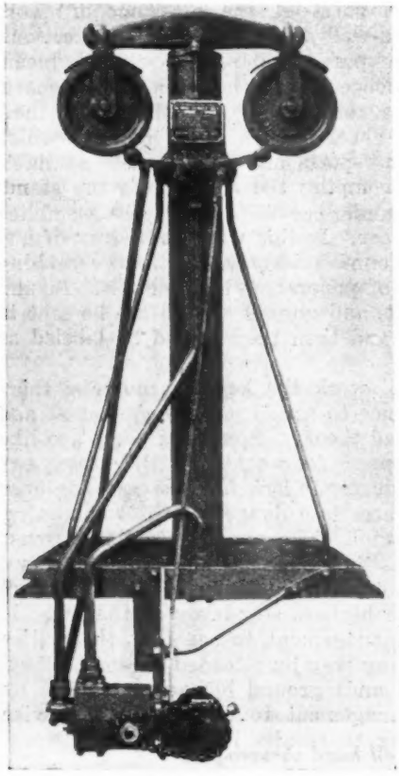
Hydraulic Hoists on Motor Trucks

In the case of the motor trucks the dump body is generally hoisted hydraulically. Owing to the presence of a gasoline engine on the truck, mechanical power is available for the hoist, and generally a take-off from the gearbox permits of the engine power to be used in operating the pump for a hydraulic hoist or in running any other unloading device which can be mounted upon the truck itself.

Hydraulic hoists are made in either vertical or slanting installations. With an hydraulic hoist it is important that the load be properly distributed so that when the outfit is installed on the chassis, the chassis is not called upon to take care of any undue strain; there must also be no undue strain on the hoist.

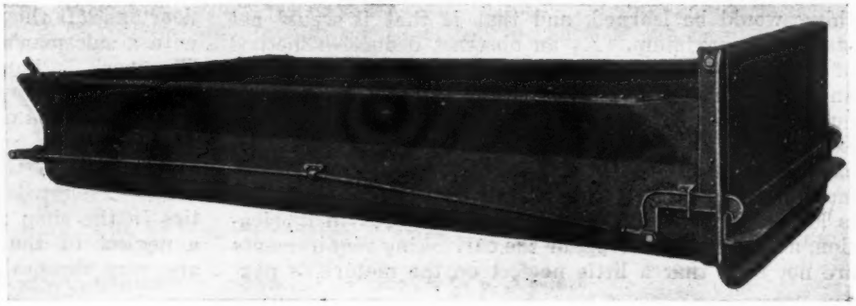
With a recent type of hydraulic hoist it is possible to dump a capacity load in about 15 sec. After the commodity is dumped it is not necessary to keep the truck at rest. The driver can start on his return trip and the body will of itself come back into position. This may appear on the surface to be a small item, but when figuring cost on a job, is is a saving of time such as this that makes the job profitable.

As compared with manual unloading or hand-operated gear trains for raising the dumping body, the hydraulic hoist is so far superior that it requires only a relatively

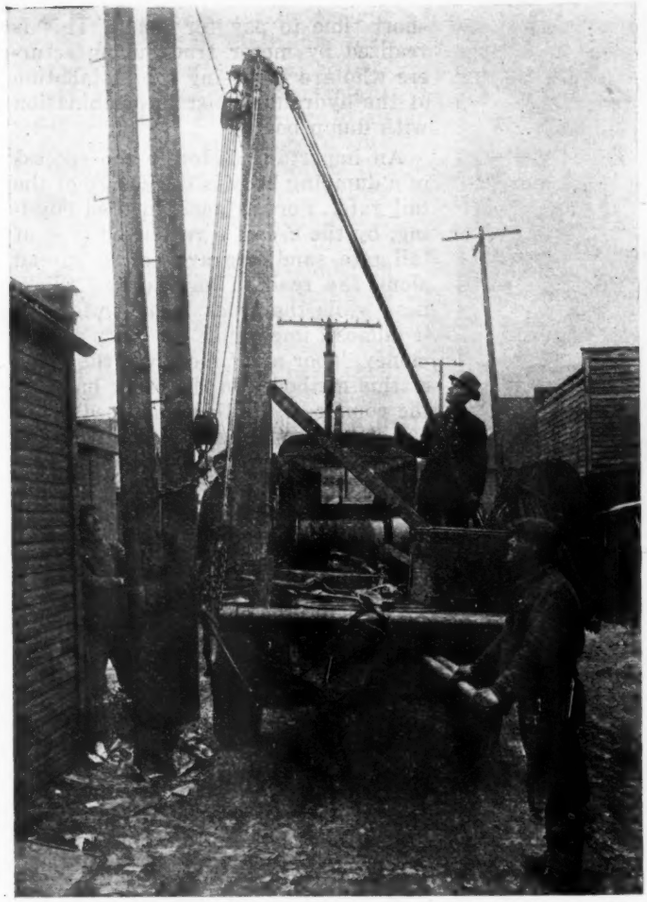


Left — Wood hydraulic hoist. Weight, 325 lb.; capacity, 3 tons.

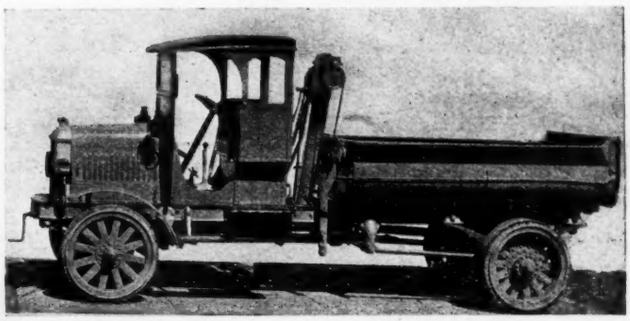
Below — All-steel dumping body with driver-operated tail gate latch



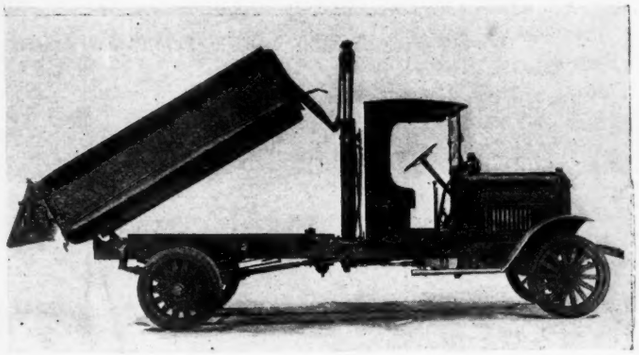
Variety of Hoists Used to Economize Time



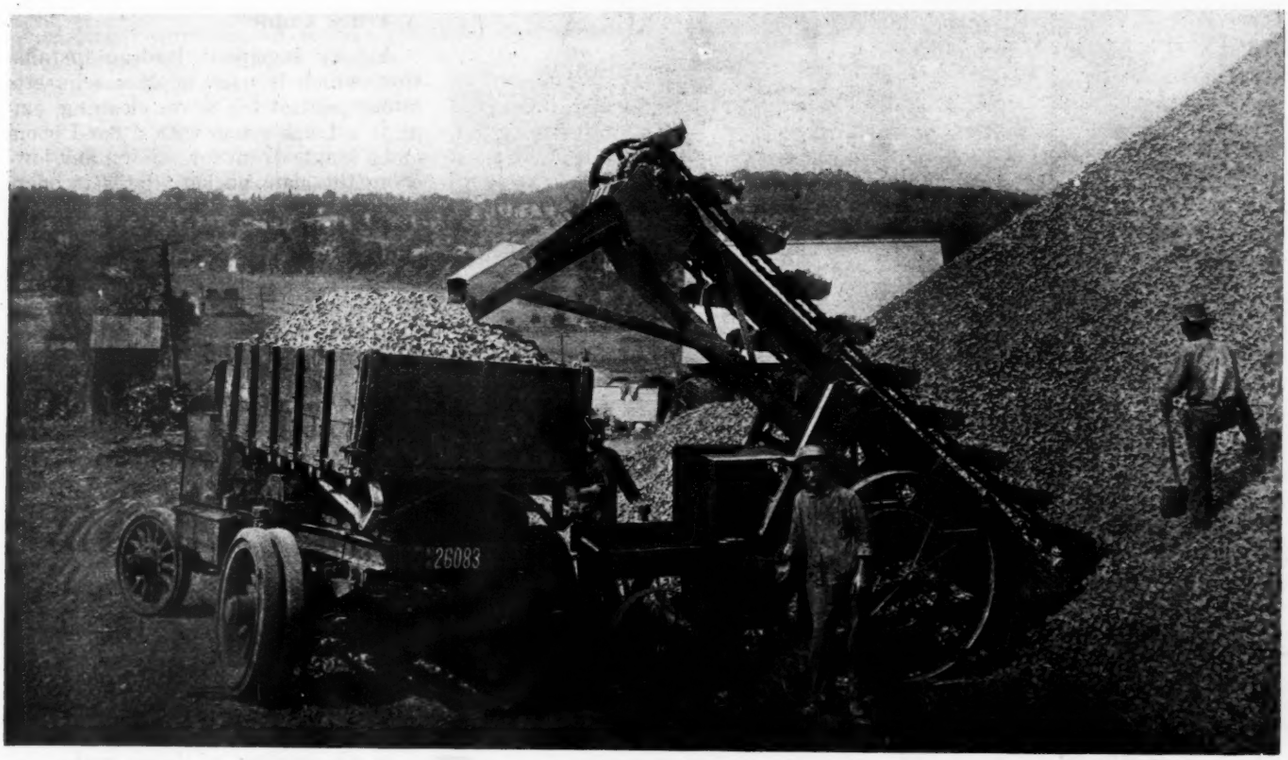
Winch-equipped truck for telegraph pole installation



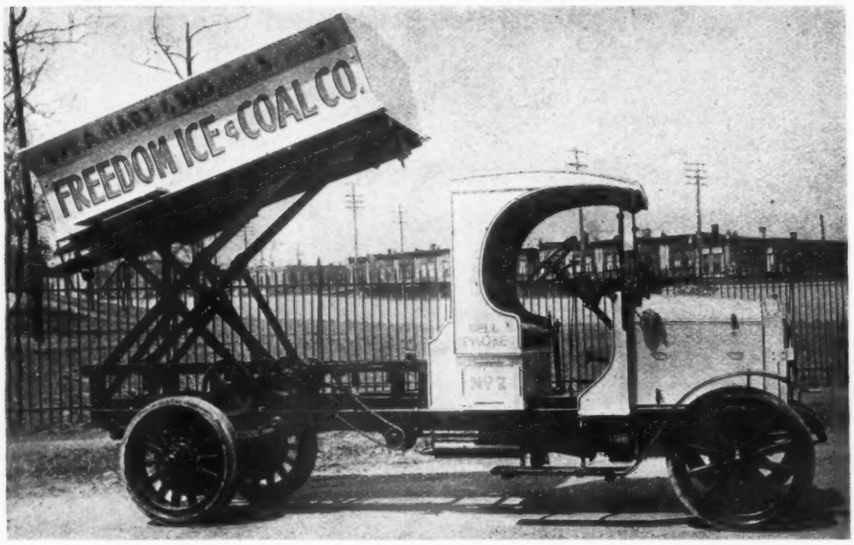
Slanting type of hydraulic hoist installation



Vertical type of hydraulic hoist installation



Haiss type of digging wagon loader, eliminating practically all hand shoveling



Dump body raised by power take-off on transmission system

Galion device for unloading hopper type freight cars into wagon by means of hoisting device, reservoir and chute

short time to pay for itself. This is realized by motor truck manufacturers who are indorsing the installation of the hydraulic hoist in combination with dump bodies.

An important factor in the success of a dumping body is the design of the tail gate. For instance, in road building, by the use of a restricted type of tail gate, sand or gravel can be spread along the road in any desired thickness while the truck is in motion. It is almost impossible to calculate in money, labor and time saved the value of this method. On the other hand, if the commodity is to be dumped all in one spot, it can be placed just where it is needed, and by the use of the vertical hoist the body can be quickly raised to the proper height. The angle to which the body must be raised has been worked out for various materials.

The hydraulic hoist for a 5-ton truck weighs approximately 500 lb. in the heavy-duty type; that is, a 500-lb. hydraulic hoist will have a capacity up to 7 tons. Such a hoist requires a space of about 15 in. between the body and the seat, if installed vertically, or from 18 to 20 in. if slanting. The lightest type of hydraulic hoist, designed for trucks up to 2-ton capacity, but capable of lifting up to 3 tons, weighs approximately 325 lb., and requires a space of 13½ in. between the body and seat. On this type the body arms are outside the chasis frame.

A Truck Crane

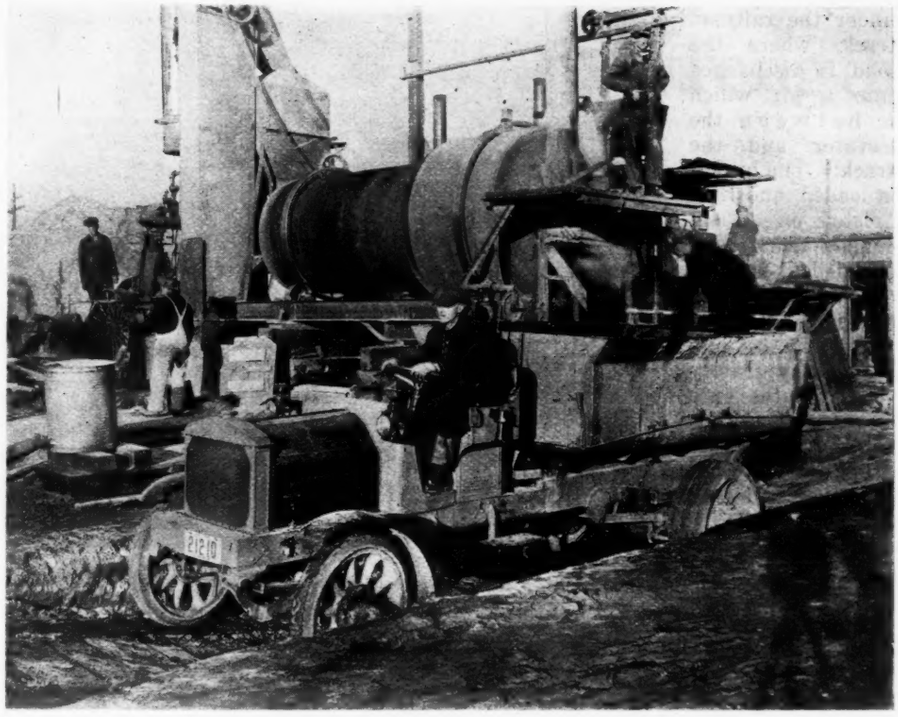
A very ingenious loading installation, which is used by Massachusetts municipalities for sewer cleaning, employs a truck crane with a fixed boom and a single drum for raising and lowering the clam bucket. This is operated by a direct take-off from the transmission gearset, and is mounted on an extension on the side of the truck frame, as illustrated. The clam bucket itself is opened and closed by compressed air, the air compressor which the installation comprises being driven from the transmission shaft. This arrangement can be made either automatic so that the clam bucket opens after it has been lowered, and closes when the hoist starts, or it can be made manually operated so that the opening and closing can be timed at the will of the operator. The crane swings the loaded bucket over the body of the truck, and it is dumped by the compressed-air system, which opens the clam bucket. Formerly the weighted tails were simply lowered and the cleaning operation performed by manual labor entirely.

In all loading of loose materials, particularly those which are delivered

to the loading point by freight car, it is highly desirable that gravity loading be used. Wherever it is feasible, the freight car should be brought up to an elevated track and dumped into overhead bins, from which the material can be withdrawn through some form of chute into the truck.

This method can be employed to advantage even in small-scale operations, because it not only eliminates manual labor, but after the material has been once delivered to the highest point by means of the rolling stock it requires no further power expenditure in handling it, except that required for opening and closing the chute doors.

The use of winches mounted on trucks for heavy work is practically a necessity. For instance, in telegraph and telephone pole installations, where the heavy pole has to be hauled into position and then lifted and lowered, the use of a winch effects a very material saving as compared with the old pike-pole method. Furthermore, the use of winches tends to obviate physical injury. Statistics show that truckmen compelled to lift heavy crates or other unwieldy bulks are more subject to hernia than any other class of men. For this reason alone the extensive use of lifting devices should be urged. A winch mounted on the truck platform will be found to give a wider range of utility to the truck body, particularly for contractors, who are apt to handle practically any class of work. Telephone and telegraph companies have found it necessary to maintain several trucks so equipped.



Feeding from concrete mixer directly into truck, with ground dug away to permit clearance

For handling such materials as coal, coke, stone, sand, fertilizer, and similar loose materials, from storage or cars, various types of portable loaders external to the truck itself can be employed to advantage. For instance, the continuous chain type, with closely spaced buckets, is very useful. The buckets pick up the load as the loader is pushed into the material, and are kept full by manual shoveling, if this is necessary. The buckets then deposit the load into a chute or hopper, from which it is fed into the truck. By the use of mechanical loaders of this type it is possible to cut the loading time from 15 to 20 min. down to 2 min. These figures are reported by the manufacturers of a device for unloading stone, sand, gravel, or other similar material, from a hopper-bottom car, carrying it to a bin, and loading it into a truck or wagon without the employment of any shovelers. It is figured that the cost for labor alone, loading stone out of a car into a wagon or truck, comes to about 15 cents per cubic yard when the work is done manually. With this type of loader it is claimed it will do this same work for about 2½ cents a cubic yard.

Machines of this kind are operated by one man, and as many as ten cars of a total weight of 500 tons can be moved in one day. The chief units in the construction of the loader are: frame, hoisting apparatus, bin, chute and pit, and the powerplant. The unloader is first located at a siding, and the cars are so moved that the hoppers or slides are over a chute placed

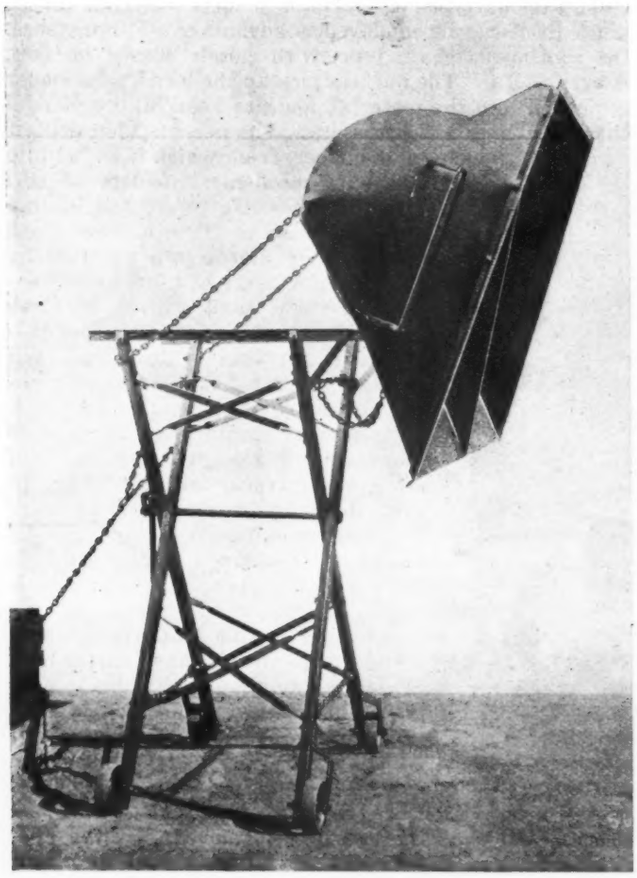
Sewer cleaning installation with power take-off from transmission and clam bucket, operated by compressed air

under the railroad track, where the load is discharged into a pit which is between the elevator and the track. The bucket is loaded, and then hoisted on an inclined track and emptied at the top of the track, into a hopper bin, from which it is discharged by gravity truck chutes into wagons, trucks or hauling cars. The drivers operate the chutes and load their wagons without delay or assistance.

Useful type of road body which can be loaded or dumped from the side

The elimination of hand shoveling is of supreme importance in saving time and money on work of this kind. As a matter of fact, it is almost impossible to get hand shovelers, because in summer there is so much other work to be had that men will not do this sort of work, and in winter conditions of frost make it practically impossible.

The manufacturer of a type of loader widely used compiled figures for comparison of costs in loading 5 cu. yd. of broken stone, coke, gravel, sand, and similar material, by hand and by a loader. His conclusion, based on cost of labor, time of use of truck, etc., was that the loading of a truck by hand cost $1.94½ and by machine 45½c. The use of the loader almost exactly doubled the number of trips that could be made by the truck.



Lee loader in dumping position

British Standard Accumulator Rating

NO value for the capacity of an accumulator is of practical use unless it is also stated at what rate the current is generally assumed to be taken from the cells.

The following rating rule for accumulators used on automobiles for starting, lighting and ignition has been adopted by the Society of Motor Manufacturers and Traders (England):

"Accumulators shall have printed on their labels their actual capacity when discharged at a definite rate continuously, this rate being one twentieth of the capacity claimed. An interval of rest to be allowed, such interval not to take place until half the period of discharge has expired.

"In every case the discharge test is considered as being completed when the pressure in volts per cell has fallen to some pre-determined value, usually 1.8 volts per cell for the 10-hr. discharge and 1.85 volts for a 20-hr. discharge as an accumulator discharged at a very low and easy rate should not be allowed to fall to as low a point as would be safe at a higher rate of discharge."

During the past year this important subject of accumulator capacity has also been fully considered by the Portable Battery Makers' Section of the British Electrical and Allied Manufacturers' Association who have considered the matter from the point of view of electrical engineers dealing with accumulators used for every purpose, including automobiles.

A standard curve has been issued by them in which the percentage values for capacity at discharge rates varying from 1 to 20 hr. have been agreed upon and accepted by the principal manufacturers of portable accumulators.

This standard capacity curve having been considered by the Society of Motor Manufacturers and Traders through the Accessories and Components Committee, they fully appreciate the value of the work done in this connection, and agree that all figures for capacity based upon the 20-hr. figures in this B. E. A. M. A. curve are acceptable to them as true values for capacity at 20 hr. rate under rating.

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THE Russell Mfg. Co., Middletown, Conn., has issued a booklet giving complete data of brake lining and clutch facing sizes used on different models of cars and trucks. The publication should be of particular use to garages and repair-shops.

Effects of Wrapping on the Strength of Struts

Found to Be of No Value When Additional Weight of Wrapping Is Considered—Bakelized Canvas Slightly Increases the Strength of Strut, But Cotton Tape Does Not

By T. R. C. Wilson*

THE wrapping, partial or entire, of certain airplane members such as struts or wing beams has been more or less commonly practised under the supposition that such wrapping aided in (1) increasing the strength at critical points, (2) holding the members together in case of partial failure, thus preventing sudden failures, and (3) keeping out moisture.

Wrapping has been advocated especially for cross-grained material in order to make available for airplane construction spiral-grained stock which would otherwise be rejected.

Extensive tests conducted by the Forest Products Laboratory of the Forest Service for the Air Service of the Army and the Bureau of Construction and Repair of the Navy on cross-grained, untapered spruce struts of the same outside dimensions covered with bakelized canvas gave the following results:

	(1) 2-Ply canvas covering (12 struts)		(2) 4-Ply canvas covering (12 struts)	
	Q	Q/W	Q	Q/W
Average	2922	619	2672	480
Maximum	3500	750	3200	580
Minimum	2425	532	2100	361

Q=Maximum or crippling load in pounds.
W=Weight of strut in pounds.

The deflections in inches of the struts which were tested to destruction were as follows:

	(3) 2-Ply canvas covering (3 struts)			(4) 4-Ply canvas covering (5 struts)		
	E.L.	T.	F.	E.L.	T.	F.
Average	2.0	4.9	6.3	1.7	6.1	7.8
Maximum	2.3	5.0	7.1	2.5	6.5	9.8
Minimum	1.7	4.8	5.0	2.1	5.5	6.3

E.L., T., and F. mean deflections at elastic limit, at first audible cracking of wood and at final failure of strut (rupture of canvas), respectively.

Four struts were tested to maximum load with the canvas on; the canvas was then removed and the struts again tested to maximum load. The average results and relative efficiency of different coverings follow:

	With canvas covering X			Canvas covering removed			Solid wooden struts of same dimensions as in X computed values		
Plies	Q	W	Q/W	Q	W	Q/W	Q	W	Q/W
2	3362	4.59	732	3012	3.53	852	3885	3.89	998
Per cent...	100	100	100	90	77	116	115	85	136
4	2587	5.59	465	2145	3.43	636	3460	4.12	855
Per cent...	100	100	100	83	61	137	134	74	184

Four struts were tested to maximum load with canvas full length after which the canvas was removed from the outer thirds of the length and the struts were again tested to maximum load.

The average results follow:

	Entire length canvas covered			All canvas removed from outer thirds of length		
Plies	Q	W	Q/W	Q	W	Q/W
2	2800	5.02	558	2590	4.30	603
Per cent...	100	100	100	92	86	108
4	2300	5.58	414	2003	4.17	484
Per cent...	100	100	100	87	74	117

Average results of tests of cross-grained Sitka spruce and Douglas fir struts (taped and untaped) follow:

Struts Wrapped with Cotton Tape and Given Three Coats of Dope.
10 *Pairs Sitka Spruce.*

	Weight (W) Lbs.	Maximum Load (Q) Lbs.	Q/W	Deflections At E.L. Ins.	Deflections At T. Ins.	Load at T. Lbs.
Taped	3.49	1262	362	2.1	6.2	934
Untaped	3.24	1276	394	2.0	6.4	910

Struts Given Two Coats of Wood Filler, Wrapped with Cotton Tape and Given Four Coats of Dope.
10 *Pairs Sitka Spruce*

	Weight (W) Lbs.	Maximum Load (Q) Lbs.	Q/W	Deflections At E.L. Ins.	Deflections At T. Ins.	Load at T. Lbs.
Taped	3.37	1197	355	2.5	3.9	993
Untaped	3.25	1285	395	2.1	5.2	1046

10 *Pairs Douglas Fir.*

	Weight (W) Lbs.	Maximum Load (Q) Lbs.	Q/W	Deflections At E.L. Ins.	Deflections At T. Ins.	Load at T. Lbs.
Taped	3.94	1480	375	2.8	5.0	1262
Untaped	3.63	1406	387	2.2	5.4	1121

E.L.= Elastic limit. T.= Tension failure.

These struts were of the tapered type used in the J-I training plane. All had cross grain of greater or less degree. Each taped strut was cut from alongside an untaped one. Before taping all struts were the same size.

The conclusions from all tests are as follows:

The addition of bakelized canvas to cross-grained struts, (1) increases the load somewhat but decreases the load per unit weight, and (2) increases the deflection and work to final failure and hence the shock-resisting capacity.

Wrapping cross-grained struts with cotton tape according to standard methods has no appreciable effect on their strength properties. It is doubtful if any other methods of wrapping such as cording would increase the strength properties very greatly. There is also the probability that any wrapping or covering will be loosened by weather changes.

It is believed that wrapping is of less value than the same *volume* of wood, and since the wrapping is likely to be heavier than wood it is of still less value compared to the same *weight* of wood.

*Engineer in Forest Products.

Landing Fields for Commercial Aviation

Some Considerations Entering Into Their Location and Design, as Determined by Army Aircraft Officials

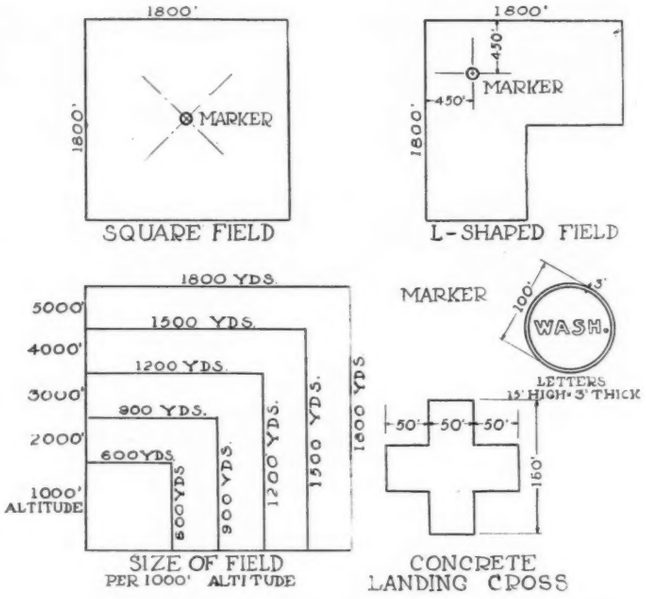
ACCORDING to army and other Government officials, landing fields are of the highest importance when it is attempted to establish commercial aviation routes, and the many elements that enter into their construction must be fully considered. Although no complete and comprehensive analysis has yet been made of all the factors that should be taken into account, some reports have been made on the subject and rules and regulations established by the War Department.

Because of the thinner atmosphere in districts located at a relatively high altitude, it is necessary to make the fields in such districts of greater length, to make it possible for the machine to attain a greater speed within the length of the field and thus insure the same rising power. For determining the necessary length of the field the War Department has developed a formula by which the length of the field necessary at sea level is multiplied by the ratio of the average weight of dry air (in pounds per cubic foot) at sea level to the average weight of dry air at the altitude considered. This gives the required length of the field at the altitude in question. The accompanying chart and table illustrate this method.

The height of surrounding country, the accessibility of the field from the port of call, the character of the soil and the prevailing winds are other important considerations. A landing field properly constructed according to the War Department specifications published herewith must have the point of landing at least 1200 ft. from the nearest obstacle 100 ft. high, 500 ft. from the nearest obstacle 60 ft. high, etc., including as obstacles trees, buildings or other construction, and hills.

To mark the fields so they can be distinctly located from great heights the army uses either a concrete landing cross measuring 150 ft. in each direction, or a circle 100 ft. in diameter with an outer ring 3 ft. wide and with letters 15 ft. long and 3 ft. thick.

Where fields are built in sections that suffer from considerable wet weather or frost, sand foundations should be used to prevent either mud or rough frozen ground.



Landing field length factor plotted against altitude

Data for Use in Calculating Necessary Length of Landing Fields

Altitude in Feet	ρ	l_o/l	$\sqrt{\frac{l_o}{l}}$
0	.0768	1.00	1.00
2,000	.0730	1.052	1.026
4,000	.0685	1.121	1.058
6,000	.0639	1.201	1.094
8,000	.0601	1.278	1.131
10,000	.0565	1.359	1.165
12,000	.0531	1.446	1.203
14,000	.0497	1.546	1.243
16,000	.0467	1.543	1.283
18,000	.0439	1.748	
20,000	.0412	1.863	

ρ = average weight of dry air in lb. per cu. ft

ρ_o = weight of dry air in lb. per cu. ft. at sea level.

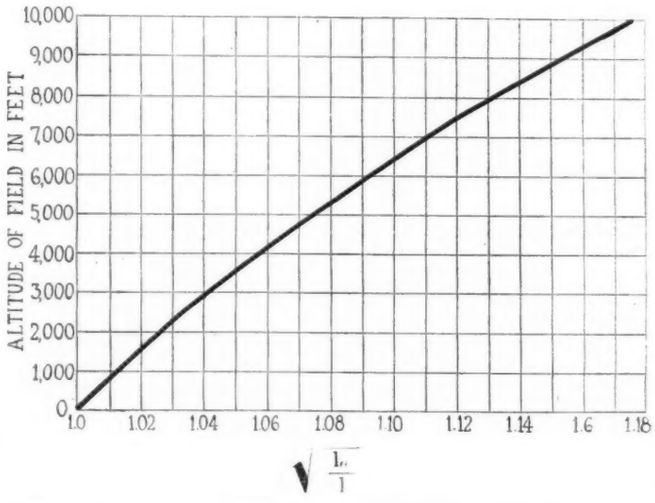
From formula.

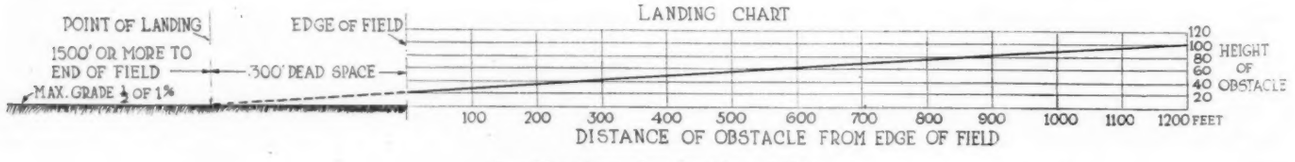
$$L = Ky\ Av^2 = C\frac{l}{g}Av^2$$

$$v = \sqrt{\frac{g\,W}{C\,\rho\,A}} = \sqrt{\frac{\text{const.}}{l}}$$

L = lift = W = weight

Since l is the only variable, the velocity varies as $\sqrt{\frac{l_o}{l}}$





Specifications for landing fields

Emergency fields, which do not have to be so complete as the permanent landing fields, should be particularly numerous in hilly country where it would be difficult to effect a landing. To insure absolute safety, the fields should not be further apart than twelve times the service ceiling of the airplane used. It is generally estimated that an airplane can make a forced descent six times as long as its service ceiling. For example, the Curtiss planes used in the air mail service have a ceiling of 1 mile. In case of trouble they can glide down over a distance equal to six times their ceiling, or 6 miles, and consequently if emergency fields are located 12 miles apart, the planes, when forced to land, are always able to reach a field.

Fields of this character, being used only in emergencies, need not be given the attention of permanent fields and can be considerably smaller. An airplane can land on a field 500 ft. long, although it might not be able to rise from it.

In deciding upon the location of a hangar on a field, the direction of the prevailing high winds must be studied. Properly arranged, a hangar will serve to take the brunt of the usual prevailing winds and act as a protection to the field and to the airplanes landing on it. At the same time the hangar cannot be built so that the winds will blow across the entrance.

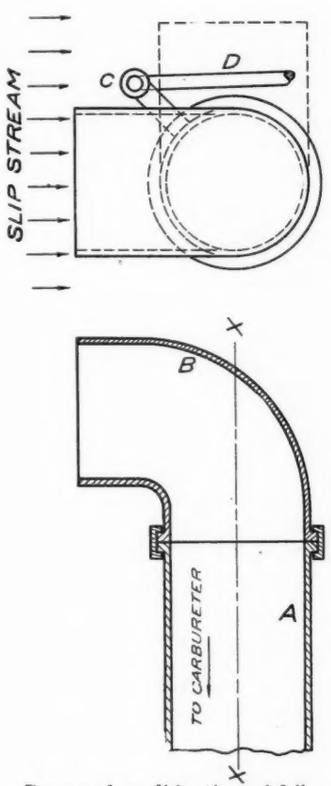
There is considerable danger of injury to planes leaving or entering a hangar if the entrance is not shielded and so built that the winds strike the back of the building instead of across the doors.

A Suggested Modification for Liberty Carbureter Air Intake

By C. V. Elliott

IN the March, 20, 1919, issue of AUTOMOTIVE INDUSTRIES two views were shown of the air intake used on the Liberty aircraft engine. The article states that the intake pipe is cut off at an angle so that pressure may be produced by the propeller slip stream.

Some time ago the writer experimented upon the effects of a stream of air passing the end of a small tube when the tube axis was at different angles with the direction of the air current. The tube was connected to a U tube manometer containing water which indicated any suction or pressure that was produced at the end of the tube. If these experiments of mine are comparable with the conditions existing at the carbureter intake, it would seem that the angle at which the air intake for the Liberty aircraft engine is cut off is about the proper angle to reduce the effect of the propeller slip stream to zero.



Proposed modification of Liberty carbureter air intake.

This at once suggests a modification of the design by which it might be possible to increase the power of the engine at high altitudes and at the same time partly compensate for the increased richness of the carbureter mixture at high altitudes. Some of your readers who may have the facilities might be interested in trying the design here illustrated and explained.

In the illustration, *A* represents the vertical carbureter intake pipe to the top of which is attached the elbow *B*. *B* is fastened to *A* in such a manner that it may be rotated about the vertical axis *X-X*. *B* has a lever arm *C* attached to it so it can be rotated by a rod *D* running to the dash.

When the opening of the elbow squarely faces the slip stream, the total air pressure in the intake would be the sum of the atmospheric pressure plus the pressure equivalent of the slip stream velocity. With the elbow turned 90 deg. from facing the stream, a suction instead of an impact would be produced in the intake, the value of which varies with the velocity. At some position intermediate between these two, the slip stream velocity would have no effect upon the pressure in the intake.

The probable effect upon the mixture would be to make it leaner when the elbow faces the slip stream and richer when at a right angle. If the carbureter were adjusted to give the correct mixture with the elbow at a right angle with the slip stream and then turned facing it, it should partly compensate for the effect of decreased air pressure at high altitude. With the elbow facing the stream, it should also be possible to get an increased weight of mixture into the cylinders, hence, more power.

If anyone should try this or has already tried it, the writer would be pleased to learn of the results.—C. V. ELLIOTT, *Instructor in Mechanical Engineering, Louisiana State University.*

Carburetion of Low Grade Fuels

(*Continued from page* 1259)

changed a number of manifolds along these lines, and in every case there has been a decided increase in power and fuel economy; in some cases both were increased as much as 25 per cent.

On large engines, where the manifolds are of considerable length, and especially on heavy duty marine engines, the distance the fuel has to travel becomes a serious factor, and it is well to consider the advisability of using a carbureter for each cylinder or for each pair of cylinders. In such cases a side outlet carbureter, where the fuel passes from the mixing chamber to the engine cylinders by the shortest possible path, is the most effective.

It is also essential to make a close study of the mixture velocity in the mixture passages. No doubt there are designers with plenty of experience who can estimate very closely the necessary velocity, but for truck, tractor or marine engines, in which most of the low grade fuel is used, it is advisable to make up several manifolds giving different velocities, and thus develop the correct size experimentally. This applies also to a certain extent to automobile types. It is the writer's opinion that for most of the work above mentioned, a limited full load speed is desired, and after all other parts of the design have been settled, it is well to reduce the manifold area until it just begins to affect the maximum power. This will unquestionably produce the best results.

ONE of the noteworthy consequences of the war, according to *Metall und Erz*, is the great increase in the output of wolfram (tungsten). Before the war the whole world production did not exceed 10,000 tons annually. The present output is at least double that quantity. An approximate estimate gives: Portugal, Spain, France and Great Britain, 2500 to 2800 tons; North America, 6000 tons; South America, 3000 to 3500 tons; India, Siam, the Malay States and Australia, 5500 to 6000 tons; China and Japan, with Indo-China, 800 to 120 tons.

The FORUM

Ensign Heavy Fuel Apparatus

By O. H. Ensign

A CARBURETOR with an inherent correct-mixture characteristic dependent upon the principle of design (rather than on experimental or scientific development by combining certain compensating elements) is especially valuable with low-grade fuels. The carburetors described herein fulfill these conditions. The basic design of these carburetors is shown in Fig. 1. Fig. 2 shows a horizontal section through this vortex mixing chamber. The air enters the metering chamber X tangentially and flows downward to the outlet K of the chamber, following a helical path. The air inlet is of the same size as the engine manifold (the nominal carburetor size) and the velocity is nowhere higher than in the manifold. The pressure drop at the center of the vortex mixing chamber X is the result of centrifugal action, plus the small entering velocity head. With air only, this pressure drop at all speeds is directly proportional to the velocity head in the air horn or manifold, averaging about five and a half times that head.

When operating normally, the fuel drawn in at the center of X is thrown by centrifugal force through the revolving air and attains its maximum velocity near the rim of X. In so doing it absorbs from the air the energy necessary to attain this velocity, thereby causing a drop in the whirling speed of the air, which in turn acts to reduce the suction on the fuel applied through the suction outlet D. In other words, we have a centrifugal pump with an air impeller operating under suction lift only, against a restricted orifice, but this pump is flexibly impelled and slows down with the added load of fuel with each increment of added motor load, so that there is an inherent tendency to thin the mixture as the load increases, instead of a tendency to enrich it. The mixture characteristic can be changed by the operator only with reference to the general fuel-to-air ratio, but not for any particular speeds and loads.

Vaporization of the lighter constituents of the fuel also causes an added drop of suction at D, as their expansion partially eliminates the vacuum, so that the more volatile the fuel, the less will be used. The more you heat the mixture by means of hot air and increase the vaporization, the less fuel will be used. In other words, the better adapted the fuel is for economical use in the motor, the less of it the carburetor will deliver, and this applies throughout a wide range of temperature. There is no need of adjustment for temperature changes, but adjustment will be required when changing from one fuel to another of far different volatility. This characteristic makes hot air the most effective method of heating. The rate of revolutions about the center of the mixing chamber X reaches 15,000 per minute in some installations. The heavy particles of fuel will be thrown to the outer wall and brought into the fresh air stream repeatedly, thus "aerating" the fuel to the maximum, if such a term can be used, and those heaviest fractions which reach the holes J at full load will pass through them under an atomizing pressure of about one-fourth of the total pressure drop through the mixing chamber, which may reach 30 in. of water when the proper size carburetor is used. Hot air in this mixing chamber aids materially, because the reduction of viscosity allows better breaking up of the fuel. At low throttle, all the heavy particles will be carried through the by-pass tube Z and ejected above the throttle at O. The natural mixture characteristic of this carburetor on modern gasoline is from 16 to 1 by weight at no load to about 17 to 1 at full load, with a straight line mixture inherently produced between these two points under all conditions of operation. The unbalanced butterfly E is used only for automobile work, when manifold conditions make it difficult to get extremely low idling. However, on an ordinarily geared machine at 7 to 10 m.p.h., this unbalanced butterfly lies horizontally and offers no resistance. It is not in any sense a choke and does not affect the pressure on the mixture at any time more than ⅛ in. of water. With this metering characteristic and this tremendous aeration of the fuel, it is naturally a low grade fuel instrument, and 90 per cent of the factory output of the Ensign Carburetor Co. has been for other fuels than gasoline—mostly kerosene.

Fig. 3 illustrates the side outlet carburetor in this type, for use with block motors with or without integral manifold.

With this straight line mixture and the manifold construction outlined above, combined with the proper application of hot air, there is not as much risk from pre-ignition as there would be where there is a possibility of a stratified mixture and poor distribution.

To still further eliminate the difficulties arising from starting and handling of low grade fuels, especially kerosene and similar products, the Ensign fuel converter, shown in Fig. 4, has been developed and it is believed to have reached a stage of perfection. This instrument uses the same metering system but adds a gas producer, a priming chamber and a thermostat.

Under all conditions of operation the heavy fractions pass through the fire screen U by gravity, over the distributer C into the combustion chamber Q and are there ignited by the spark plug which is in series with one of the cylinder spark plugs, or may be supplied from a special distributer. There is formed a continuous downward flame, and partial combustion takes place, because the suction through the gas flue Z puts the flame out before combustion is complete, delivering a fixed inflammable gas above the throttle. The heat developed by the gasification of the heavy particles of fuel causes a rise in temperature of the floor of the mixture passage L, the walls of the gas flue Z and adjacent parts, vaporizing the lighter particles of fuel, so that the resulting mixture is composed of vaporized fuel, free carbon, fixed gas, a certain percentage of inert gases and steam. The throttle is provided with a notch O, into which a square plug M, operated by the thermostat capsule N, is projected by action of the heated mixture, which is forced to flow about the capsule N, thereby regulating the opening of the notch O to control the draft through the flue Z when the motor is idling, and thus regulate the idling temperature.

With the throttle wide open the draft through the flue Z is an induced draft, brought about by the elbow of the main mixture passage, the obstruction offered by Z, etc. The idling temperature is limited to something under 235 deg.; the load temperature varies according to the motor and other conditions, from 235 deg. down to 160 deg. In other words, the temperature is

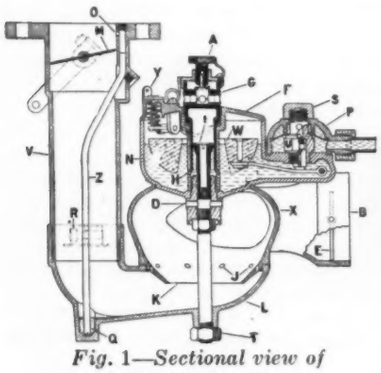


Fig. 1—Sectional view of Ensign carburetor

Fig. 2—Horizontal section through vortex mixing chamber

highest with the lightest load and lowest with the heaviest load. The by-pass V takes air relatively free from the heavy fuel mixture, out of the upper part of the mixture passage L, and compensates for the tendency of a large portion of the fuel to flow into the fire box when starting cold or in cold weather. Also, it furnishes relatively clean air to maintain a higher rate of combustion under those conditions, while in warm weather the heat travels up into the mixing chamber X, and some of the lighter particles of the fuel will be vaporized and pass through V, smothering the fire. Thus the apparatus inherently compensates, to a great degree, for changes in temperature and changes in the end points of the fuel.

It is started by means of a gasoline primer in the chamber E. At the top of this chamber is a large hole which overflows when priming cold, and a puddle of gasoline will form under Z. With the throttle closed and the plug M withdrawn, the engine is sure to get a good mixture for starting. Gasoline continues to feed, at a reduced rate, for a short time, until the cup E is empty. However, the instant a spark occurs in the combustion chamber, there are formed a fixed gas and heated vapors that will operate the motor in the coldest weather. Starts have been made at 16 deg. below zero, which permitted of putting the motor to work immediately, and within the short distance of a city block full power on kerosene was obtained. It starts on a kerosene prime from D when hot and a few drops of gasoline from F when warm. The inverted cone B is of a refractory cement, practically indestructible. The small threaded rod standing in the flue Z has a vertical movement of about 1/16 in. and under the suction and the jar of the road, moves around in the flue Z, removing any carbon which may collect in the flue.

This offers an instrument for handling any water white fuel from gasoline through to kerosene, with no change in the instrument other than adjustments of sleeve G, with a change in the viscosity of the fuel, except that in warm weather when running on gasoline the spark plug in the combustion chamber should be short circuited. The instrument then becomes a gasoline carburetor.

With this instrument ideal manifolds are not necessary, but are an advantage. It can be started to work immediately, which is more than can be said of present gasoline equipments, when cold weather conditions are considered.

The pressure of a certain percentage of inert gases (carbon dioxide, carbon monoxide and methane) in the mixture will obviate pre-ignition under compressions which with any other method of heating kerosene would cause serious trouble.

When operating at extremely low speeds under small throttle, the thermal value of the mixture is lowered, because a very large percentage of all the fuel is drawn through the fire box and converted into fixed gases, but as the throttle is opened up, the thermal value of the mixture increases. The all-around average result on many commercial installations indicates an average of one-third less kerosene used than with gasoline. This, of course, is due to better distribution to all cylinders and a uniform performance on a thin mixture, as well as to a slightly increased thermal value of the fuel used. Some block tests have been made in which the horsepower exceeded that obtained on cold gasoline, under the same conditions. This was undoubtedly due to the fact that the distribution to the cylinders was very materially improved.

An entire change of the character of the mixture occurs with extreme changes of atmospheric temperature, for in extremely cold weather, no doubt, a very large portion of the fuel passes through the fire box all the time, because it simply is metered by the chamber X and not broken up to any extent, and probably this fuel, passing through the fire box, is cracked to a certain degree to some lighter fractions, as it has to pass through the flame zone. Also, during cold weather a very persistent fog is created by these vapors of fuel, which pass through the flame zone and are delivered above the throttle, by contact with the colder mixture, going around the outside of the flue Z.

The apparatus has been in continuous operation for over two years. Throughout this period the motor was in better condition, with less repairs than with any other method of carburetion, and within the last six months it has been possible to operate without unusual attention being given the converter.

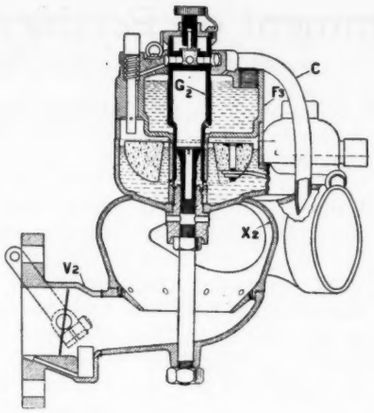


Fig. 3—Side outlet carburetor for use with block motors

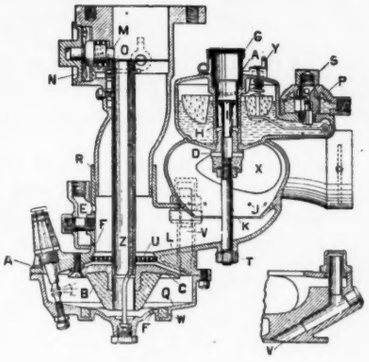


Fig. 4—Ensign fuel converter

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Odd Ways of Starting Gas Engines

By Jack Hiscock

NOT every motorist as he presses his starter pedal, stops to think how fortunate he is that the process of cranking the engine has been so simplified for him. Electric starters were developed because the old method of cranking by hand proved intolerable. Yet, hand starting of an automobile engine is child's play compared with the methods necessary to start some other types of engines.

When a tractioneer starts the engine of his big caterpillar, he fits a bar into one of a series of sockets in the engine's flywheel and rocks the engine up to compression. No one can spin these monsters. Rarely can they be rocked past compression, but are usually rocked backward up to compression, where, thanks to generous priming and a hot spark, they usually fire and the wielder of the pinch-bar pulls it from the darting socket hastily.

The petty officer on a submarine chaser relies upon compressed air to start his unwieldy engines. He, too, must prime copiously and has the additional responsibility of an auxiliary engine, hand-started to pump the air.

A most picturesque but risky method is ordinarily used to start airplane engines. The mechanic shouts "Off" as he approaches the propeller and is answered in kind by the pilot at the switch. He then spins the great wooden blades by hand to charge the cylinders with gas. Having worked up a warm perspiration, even on the frostiest mornings, he springs clear and shouts "Contact!" The pilot indicates that he has closed the switch by repeating the signal and the mechanic once more approaches the propeller. Gingerly this time, however. With a single swift motion he twirls the blade through an arc of more than 90 deg. and steps quickly away from and to the side of the murderous whirling stick.

A 150-hp. engine is about all anyone but a Samson can swing. When heavier engines, culminating in the 400-hp. Liberty, made their appearance, new methods had to be devised. At first the blade was pulled over compression by running past it and giving it a smart pull in passing. Sometimes two men with hands joined were required. As many as three were required to do the preliminary "winding up" or charging. Owing to the weight and complication, electric starters were not considered seriously, but an auxiliary magneto was made use of to produce a shower of sparks in the cylinder under compression.—JACK HISCOCK, *Splitdorf Electrical Co.*

Engineering Comment on Pertinent Questions of Design

(*Continued from page* 1255)

close as possible to the cylinder walls and have arranged the gas passages as free from bends as possible. This has given very gratifying results, even in the lower speed range.

I am not in favor of a piston speed above 1500 to 1600 ft. per minute on account of the lack of time necessary to vaporize the fuel at higher speeds. With low-grade fuel the time available for vaporizing, compressing, and exploding it is too limited to permit combustion of the full charge, and necessarily part of the gas stays in the cylinders in the raw state and filters into the crankcase by the piston rings, thereby cutting the quality of the oil and causing bearing troubles.

The Pistons

I think the hour-glass type of piston and the broken wall piston will have a restricted use, as, for instance, in flying machine motors or racing motors, but I cannot see how anything but the full cylindrical type can be used in the everyday motor. Everyone must realize that in the gas motor, the piston is not quite as well guided as in the steam engine and, therefore, the bearing of the piston into the cylinders must be made long enough to insure a perfect joint and a compression chamber absolutely tight. As the film of oil, which is between the wall of the pistons and the cylinder, plays a great part in gaining that object, it must not be broken in the length of the piston in order to have the greatest efficiency. There is also the trouble known as piston slap, and this can be avoided only with a piston bearing as long as possible and unbroken. In fact, I think that we could have better motors to-day if we would lengthen our pistons slightly instead of trying to shorten them. At least, it would give the motors a great deal longer life.

My experiments with the different types of aluminum pistons have not convinced me yet that it is the proper piston to use in a motor. Neither the heavy type nor the die cast aluminum piston has been proved satisfactory, and especially since, with the fuel we are using, we must prevent, by all possible means, the passing of the raw gas by the pistons into the crankcase, the aluminum piston is certainly at a great disadvantage as compared with the cast-iron piston. For limited service in specially built motors for racing cars and flying machines, I consider the aluminum piston a necessity, but for continuous and heavy service, nothing has yet appeared to take the place of a well-designed cast-iron piston.

I cannot see any chance for a radical change in the transmission. I think that a great deal of the noise caused by the meshing of the first and second speed gears could be avoided if the transmissions were designed with wider and heavier bearings, also with heavier shafts, avoiding the deflection of the shafts under load. The practice of making secondary shaft gears and their shaft revolve together on two outer bearings should be abandoned, because the load is applied only on one point and has a tendency to bend the shaft and, of course, makes the gears run out of true, thus causing some noise. The best plan is to have the countershaft gears in one unit revolving on a fixed heavy shaft. This tends to eliminate any chance of deflection and to distribute the load evenly along the full length of the shaft. The gears will run smoothly and noise will be eliminated.

Rear Axles

I do not think that the rear axles are too strong on any car. Some of them might be too heavy and some better design, no doubt, can be evolved which would reduce the weight and make a better axle. But in my opinion the rear axle of the average car could be made stronger and better by using larger bearings, also a higher grade of steel for the shafts, and a special heat treatment of the steel tubing, permitting the use of a lighter section with a high elastic limit. An electrical treatment of steel tubing has been devised recently which increases the elastic limit of the tubing by 100 per cent and, no doubt, this could be used in making a rear axle stronger and lighter at the same time.

In my opinion the great majority of cars on the market have very poor brakes. The reason, I believe, is that we apply the braking power on the slowly revolving rear wheels with less effect than if we applied the power to the transmission shaft revolving at a high speed. No doubt the reason for putting the brakes on the rear wheels has been that most of the automobile plants of this country are located in flat country, where designers do not have the opportunity of trying the cars on mountain grades. If some of the automobile factories were located near the Rocky Mountains, no doubt we would have better brakes because, in testing the cars, the engineers would find that the present brakes would not take a car down a grade seven or eight miles long without burning the motor and having to brake with the motor. Foreign cars are better than ours in this respect, for most of them are used on mountain roads, and as far back as 15 years ago their designers had studied the brake question and had transmissions with the brake drum flanged to permit the cooling of the drum by water.
—E. Planche, Chief Engineer Dort Motor Car Co.

By John Wilkinson

Super-induction charge for the purpose of ramming an excess charge in the combustion chamber is utterly futile. It makes the car heavier, it consumes more gasoline per mile, it increases the cost and the complication. The economy is less because super-induction, on account of the increased mean temperature, cannot be used with as high compression as is used in the ordinary four-cycle engine. It, therefore, follows that the thermal efficiency will be lower. Also, on account of the higher mean temperature, more radiator will be required, the exhaust pressure will be higher and more muffler will be required; and, too, on account of the same high mean temperature better exhaust valves will be required. Added to this will be the complication of a means for super-induction.

For a given horsepower, although the mean effective pressure is raised, there is no reason to look for more horsepower per pound of weight. Therefore, as first stated, the automobile will be heavier, more costly and less efficient.

In regard to pistons I can see no field for heavy aluminum pistons in small size cylinders, because weight limits the speed. Die-cast pistons are very successful in themselves.

The Riccardo type, with guiding and sealing elements. may find a considerable field in stationary practice, but in automobile practice, where high speed and light weight are necessary, this type would seem to be impossible.

From transmissions he has seen the writer believes it is quite possible that within a few years such improvements will be made in grinding gears that we may expect to get a commercially satisfactory transmission. I have already seen some special transmissions which are so much better than the average that they would seem to be good enough if used as a standard.

Most all rear axles are too heavy and when the designers appreciate the disadvantages of this weight, they will have no trouble in producing a reasonable weight axle.

I am a thorough believer in the transmission brake as a foot brake for general service. The advantages in having one brake on the transmission and one brake on the rear wheels, so as to remove as much weight from the rear axle as possible, should be evident. This results in better diffusion of the heat in braking under severe conditions and furnishes a foot brake for general service which, when applied quickly under high speed, will not throw the car into the ditch.—John Wilkinson, Vice-President H. H. Franklin Mfg. Co.

Tractor Design Problems

By L. L. Cass

I do not think it logical to restrict intake passages to govern the performance of a tractor engine. Why build for power that cannot be used? The logical method would be to apply to a tractor an engine with 25 per cent surplus power, which would be avaliable in extreme conditions. Make an engine as efficient as possible and so powerful that, except under extreme conditions, there is always reserve power. When this is done, engine trouble will be reduced to a minimum.

Comparative results obtained with both splash and pressure lubrication, which I have observed personally, prove conclusively to me that pressure lubrication is absolutely necessary, the most practical pressure being 25 to 30 lb. at 1000 r.p.m. of the engine. Positive application of lubricant is the only way to be sure of accomplishing the desired results.

The wise tractor owner is the one who insists upon using gasoline instead of kerosene. Many good kerosene burning equipments are on the market, but with the best of them there is found to be considerable crankcase dilution, more so than with gasoline. While kerosene is cheaper than gasoline, lubricating oil must be changed more often, bearings must be watched more closely and better performance can be obtained by the use of gasoline.—L. L. Cass, Chief Engineer, Parrett Tractor Co.

By H. L. Horning

If the passages are restricted for the purpose of eliminating the governor, I do not think it will be satisfactory. The farmer demands a tractor with a governor. All engines have restricted intake passages whether they are served by a governor or not. No doubt these restricted intake passages save many engines from untimely destruction.

I think pressure lubrication will be satisfactory when it is better understood by the manufacturer and the user. At present the splash is the most satisfactory system. Nothing can take the place of design and good workmanship in bearings, nor can lubricating oil be expected to cover the defects of a bad system of lubrication.

The common method of lubrication is splash, in which the level is established by overflow dams. Another form, and the most reliable, is the splash system in which the oil level in deep troughs is correctly maintained, irrespective of the inclination of the engine. The oil pump capacity in pumping the oil into the troughs is just equal to the capacity of the scoops to throw the oil out. Inasmuch as the oil pump capacity varies with the speed of the engine, and the rod scoop capacity the same, the level of the oil is constant.

Force feed through a hollow crankshaft is a well-known and high-class system. It has not been widely adopted because of the difficulties with leakage of oil under pressure, both past the piston and rings and at the crankshaft, and because of the unusual workmanship required for the pressure maintenance. In both the above mentioned systems old oil is pumped over and over, and this leads to bearing troubles.

Lubricating oil is little understood even by the refiners. Most tractor oil is so loaded with the heavier portions that under high pressure and temperature under the piston heads and walls it breaks into lighter oils, carbon and tars. Added to this, many engines suffer from dirt, dust and sand which enter either at the carbureter or breather. Taken together, the oil in the crankcase of an engine in use for a month, with either the splash or common force-feed systems, is usually a bad mixture and entirely unfit for lubrication uses.

With the force-feed system, unusual care must be taken to strain and settle all grit or dirt out of the oil, or it will cause unusual damage to journals and bearings. No such care is necessary with the splash system, as it seems to develop the least difficulties with dirty oils. With clean oil, well filtered and of good body, the force-feed system works exceedingly well so long as the bearings are in good adjustment. A surplus capacity of oil must be available at all times, so one or more loose bearings will not starve other bearings. Unusually good piston and cylinder fit must prevent overoiling of cylinders when rod bearings are loose.

The ideal system, if expense and care are no object, is the force, feed of fresh oil to crankshaft bearings and cylinder in exact quantities. So far as results are concerned on the surfaces, bearings lubricated by this method are not only the most economical in oil consumed, but also insure the longest life to both journals and bearing surfaces.

This brings us to the effect of heavy fuel on the bearings of tractor engines. Incomplete vaporization leaves heavy fuel unburned, incompletely burned and decomposed on the walls of the cylinder and combustion chamber. Under the action of high heat the fluid residue flows down the cylinder and past the rings, through the oil drain holes so commonly used, into the crankcase.

The products of complete and incomplete combustion found in crankcase oil range in hydrocarbons from formaldehyde to sugars. They include acetone, alcohols, sorghums, formic acid and a list of disinfectants varying in constitution according to the circumstances of combustion. This mixture, taken together with the solid contents mentioned above, constitutes about the worst lubricant a cylinder and bearings could have. The lower crankcase is the catchbasin for the by-products of imperfect combustion process. It is the main sewer for decomposing body fillers of our poorly compounded lubricating oils. It is the settling basin for steel, iron and bearing particles which slough off into the lubricants, and the crankcase with its oilpan forms the dustpan of the self-appointed air cleaner which duty every engine takes upon itself.

Taken from an unbiased standpoint, have engineers in tractor engines of to-day finally arrived at about the worst lubricating conditions possible? Is there any device which would permit more fuel to get into the lubricant than our present design of oil scraper piston?

The man was a great philosopher who said, "Tractor engines work in spite of the designers and users."

The heavy fuel and by-products of combustion appear

to have bad effects on steel journals and bearing materials. In England some practical men, and engineers as well, consider an engine "done for" if it is once thoroughly saturated with some of the fuel compositions.

Economic factors impose the splash system, in its most thoroughly worked out form, as being a good stand-by under all circumstances. Most men understand it best, or, to be frank, pay least attention to it. As an all-around system, it takes care of itself better than any other. The ideal system of fresh oil to all points is perfect, theoretically, but the complication and details, together with thickening of oil in cold weather, make it hard to introduce. The force feed through the crank will become widely used when manufacturers and users know more about it.

Bearings suffer under heavy fuel conditions due to the high pressure of detonation and preignition. Preignition can be controlled by design, as will be noted under cylinders, pistons and rings. Both preignition and detonation are limiting factors of our modern fuels.

It has been our policy to frankly state to our customers just how well we can burn kerosene, its limitations, and wherein it is not as good as gasoline. We have influenced a number of customers not to put on the kerosene equipment, convincing them that the decrease in the cost of the fuel per gallon did not make up for the loss in horsepower and less work done in a day.—H. L. Horning, General Manager, Waukesha Motor Co.

By R. O. Hendrickson

I believe in governing or limiting engine performance by a combination of three factors, as follows:

First—traction.

Second—piston area.

Third—restriction of intake passages.

In regard to splash oiling system vs. pressure, this depends principally on the size and revolutions per minute of the engine, the splash being more suitable for high-speed engines and the pressure absolutely essential for engines where the piston walls are at a greater distance from the crank. The splash system is much simpler.

I believe that where an engine is designed for the use of kerosene fuel, it is quite as satisfactory as gasoline, except for the additional attention required in starting. An internal combustion engine to use kerosene as fuel must be designed throughout with this in mind. An engine of the T or L head type, with large areas in the combustion space, is not very suitable for burning kerosene oil; on the other hand, an engine with a compact combustion space, with proper carbureting attachments and manifolds, is quite satisfactory.—R. O. Hendrickson, Chief Engineer, Wallis Tractor Co.

Duralumin for Metal Airplanes

IN a recent paper presented to the Royal Aeronautical Society of Great Britain, Dr. A. P. Thurston asserted that wood construction of airplanes would give way to metal construction on account of the all-round superiority of certain metals, notably steel and duralumin. As compared with steel, duralumin has many advantages and a few disadvantages. Weighing only one-third as much as steel, it follows that the various members may be, weight for weight, three times thicker than steel members. Hence the difficulty in overcoming local failure due to local flexure is greatly reduced. Nevertheless, the perfection of a design can only be discovered by constructing it in steel, and it is thought that duralumin designs will be improved by adopting the principles which have proved to be the only feasible ones in steel construction.

A prejudice appears to exist in certain quarters against duralumin owing to the fear of corrosion. It should be stated that duralumin, unlike aluminum, is not acted upon by sea water, or affected by atmospheric influences, and experience in connection with airship work shows that duralumin, if properly varnished, is not affected by corrosion under ordinary conditions of service. Nearly every case of corrosion so far experienced in actual practice has been traced back to incorrect heat treatment, or to cold working after heat treatment. The heat treatment of duralumin, instead of being a disadvantage, as is often supposed, is in actual point of fact of the greatest assistance in the practical working of the metal. This heat treatment is carried out by placing the members to be treated in a bath containing a mixture of potassium and sodium nitrates heated to a temperature of 480 deg. C. In practice there is a fairly wide margin of temperature so long as 500 deg. C. is not exceeded, in which case there is danger of the metal being burnt and reduced to aluminum. The parts should be left in the bath long enough to be heated uniformly to the temperature of the path, the actual time allowed being five minutes in the case of small units up to several hours in the case of 3 in. bar. There is no danger in leaving it in the bath too long, providing the actual temperature of 500 deg. is not exceeded. At the end of this time the article is removed from the bath and quenched out in water or non-acid oil. Immediately after heat treatment the metal is found to be in a very soft and plastic condition, and it may be pressed, forged, bent to the smallest radius, or in the case of drawn sections which have warped with the quenching, straightened without any fear of damaging the metal. The metal now commences of itself to harden up, and in about an hour's time has reached about 26 tons tensile strength, with an elongation of about 15 per cent.

This process of hardening continues for a very long period, the strength slightly increasing at the expense of the elongation. Heating duralumin to 300 deg. C. and then quenching out anneals the metal, and it can then be worked in any way desired. In order to give it back its strength it is necessary to heat treat it at 480 deg. C., as explained above. In practice it is usual to anneal any duralumin part if a number of operations have to be performed, and on the other hand to heat treat before final operation if this is not of too prolonged a nature, taking advantage of its abnormal condition immediately after heat treatment. An actual example of the value of this property of duralumin in slowly hardening up after heat treatment occurs when duralumin is used for rivets. If an attempt were made to rivet these up in the ordinary hard condition they would crack badly. By heat treating them, however, and using them immediately after this, a perfect job may be made while they are soft, and within a very short time afterwards they have hardened up to their full strength.

If duralumin in the ordinary hard condition is bent to a small radius there is, as would be expected, a probability of incipient cracks developing on the surface of the metal at the bend. These cracks are the places where the corrosion begins. If the metal was properly heat treated before such bending no injury would be caused to the surface of the metal, and no trouble would be experienced from corrosion. Nearly the whole of the prejudice against the use of duralumin is due to ignorance as to its properties with and without heat treatment. Sections cannot conveniently be drawn thicker than 0.2 in. Above this thickness the sections are extruded. It is advisable to use only solid drawn sections for the constructional purposes and designs should accordingly be modified to meet the limitations in the material.

ACCORDING to a French contemporary, American army motorcycles recently sold at auction in London brought prices above their catalog figures.

THIRTY-ONE of the leading British accident insurance companies have so far issued a list of premiums for flight risk insuranee.

Tractor Design from the Operator's Viewpoint

(*Continued from page* 1311)

The belt pulley should be where a man can either sight over it or set guide marks by stepping off from the belt as it lies on the ground. Also, the belt should clear the operator well so that he will not be caught or struck in tightening up on it. The belt pulley should not be located so that it may catch a man's clothes when not being used in belt work.

Seat springs are apt to break, and if there is any chance of a man dropping in front of a disk or other load, a safety basket should be provided. Considerable improvement might be made in the operating position it is necessary for the operator to assume. A padded or a cushion-back seat is too warm in summer, but saves a man from much jar.

It should be borne in mind that an operator must be at his post all the time the tractor is operating and is unable to run all over the machine to make adjustments and to oil the various parts of the tractor.

Care should be taken not to make individual parts, such as heads of a block motor, too heavy, as very often the operator has no facilities for lifting and has no helper.

These remarks are not intended as a criticism of any one design, nor of designers in general, for the problems involved in getting out a practical machine are not easy. Some of the operator's requirements are much more easily stated than solved, but the success of a tractor and its sale in any given neighborhood depend largely on the operator, and the easier it is made for him to keep going, the better he and the owner are satisfied. Some operators may like to tinker with their machines, but most of us are glad enough to leave them alone, unless some part is in need of attention, and the more easily that thing may be got at, the more likely it is to be fixed before trouble develops. In case of trouble the more accessible rig will get going the soonest; therefore, make your rig accessible.

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The Influence of Hitches and Drawbar Location on Tractor Design

(*Continued from page* 1335)

be provided with suitable hitches for tractor operation, and their further use should be provided for.

I do not believe that a successful tractor will ever be a very good cultivator or vice versa, because the operating conditions and requirements, as well as the power demands are too different. Therefore, cultivating implements and their attachments need not be considered in connection with the problem of tractor hitches.

So much for the problem of tractor hitches and drawbar location as related to tractor design; doubtless there will be many to take issue with me on one point of reasoning, and that is the point about which the moments of the various forces act. I have watched dozens of tractors in operation, seen them raise up and even turn over, and the rotation is always about the rear axle and not the point of contact between the drive wheels and the earth.

In proof of the reasoning employed, make of yourself a tractor in the following way, and note the reactions in your own body.

If you stand with the body bent forward at the hips, with a wooden square representing the tractor framework hinged upon a pipe or rod strapped across your back at your hips, and attempt to drag a load hitched onto the lower end of the wooden square, you will observe that the forward end of the horizontal arm of the square presses heavily downward upon your back, and that the harder you pull the more the tendency will be for you to want to straighten up. This corresponds exactly to the forces at work in a tractor, showing that the greater the resistance (or drawbar pull) becomes, the greater the effort becomes to overcome this resistance, and, therefore, the greater the tendency to raise up at the forward end.

As the framework corresponds exactly to the wooden square, and is hinged about the rear axle, it is evident that it cannot rotate about any other point.

Some engineers claim that at the time the tractor overturns it becomes practically a locked or rigid mechanism. If this were a fact the drawbar pull would suddenly have to become an active force in place of a reactive force in order to overturn the tractor, and this, of course, cannot happen.

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Waterproof Plywood for Airplanes

(*Continued from page* 1333)

ting veneer has very little effect on the strength of the plywood, but that the plywood made of sawed veneer is inclined to warp less than the plywood that is made of sliced or rudely cut veneer.

An extensive series of tests on glued and riveted joints in plywood was completed. Joints of various types were made, some of which extended through a single ply only, while others extended through the entire plywood thickness. The tests show that the tubular rivet gives the most satisfactory results in riveted joints and that there is very little difference in the strength of joints made of various sizes of rivets, provided that the most effective spacing and margin is used of each size. The scarf joint extending through the entire plywood thickness was recommended in preference to the riveted joint, because it gives a considerably higher efficiency. A scarf having a slope of from one in twenty to one in thirty was found to be very satisfactory.

Tests were made to determine the proper conditioning for plywood which is to be bent in double curvature. A special mold was prepared for this purpose, but the tests made are still too limited in scope to draw any conclusions.

Machines were devised for determining the vibrational strength of plywood and the relative toughness. The tests made to date are still too limited in number to draw conclusions.

—

Matthews Full Automatic Lighting Plants

(*Continued from page* 1315)

turn through a certain angle and is then held from rotation by an adjustable stop on the dial. If now the current through the relay should be reverse, as in cranking the engine, the relay hand moves slowly in a clockwise direction until it comes up against the contact point. This completes the circuit of the breaker trip coil, which latter neutralizes the hold coil, so that there is no resulting pull, and the breaker armature is released, thereby opening the circuit between the battery and the generator. Thus, after a fixed period of cranking the engine, which is generally about 2 min., if the engine fails to pick up its cycle the generator is automatically cut off from the battery and no undue amount of electric energy will be wasted.

The normal position of the breaker is the closed position with the hold coil energized. If the breaker opens, all control circuits are dead, and all coils and relays in the released position, and the lights are cut off.

AUTOMOTIVE INDUSTRIES
The Automobile

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European Restrictions

INSTEAD of France and Great Britain ameliorating on the question of import restrictions and the import duties to follow the removal of restrictions, the present sentiment in both countries to protect their respective industries is increasing. The reason lies in the fact that for many years America used its high tariff wall of 45 per cent against European manufacturers, and now these European makers do not especially cherish the suggestion from America that import restrictions should be removed and low import duties levied.

The probability of the removal of the British import restrictions September 1 is not so bright as it was a month ago. The 9 months of import restrictions do not seem sufficient for the British manufacturer, who has been somewhat slow in rearranging his business after the war, although perhaps not open to criticism, as the work of re-arrangement has increased as months have passed.

France has frankly stated that her manufacturers are capable of caring for the needs of the civil population in that the interests of the country must stand ahead of the interests of any particular industry. The civilian population may require more vehicles to-day than the manufacturers can furnish, but if throwing down the bars to America, because she has the vehicles at hand, would bankrupt the French industry, then the French Government is entirely rational in its view.

America is to-day paying part of the price of the high tariff duty that has always been against the European manufacturer. The 10 years when European makers had to meet the 45 per cent duty are not forgotten. As France puts it, after American makers have built up business behind a 45 per cent tariff protective wall, it is hardly good grace to tell France she should not have a high tariff protective wall to rebuild her industries after the war. If the protective wall was good for America in the early days of the industry, and up to the present, then it should be good for France to-day. Perhaps we were not so much concerned about giving our civilians cheap European cars 10 or 12 years ago as we are giving French civilians cheap American cars to-day.

The best thing for the automobile industry in America is to have a healthy automobile industry in England, France, Italy and Belgium. It would be scarcely short of a calamity to have the French automobile industry bankrupt. The same applies to the British industry. Both of these countries have played a large part in the development of the industry. The British maker played it without a protective tariff. The French maker did it with a relatively low tariff. He has been the developer. We did it with a high tariff. Because of this we should attentively listen to the requests of France and England for the protection of their industries for a given period.

As Japanese Do It

SOME American business men have expressed astonishment at the ability of the Japanese to gain and hold export trade. While the Americans knew there must be a reason, a good many of them apparently were not able to discover that reason. There are many reasons for the Japanese success, and one of them is set forth in the recent summary of foreign trade printed by the Guaranty Trust Company of New York. In the Japan report this review says:

> The Japanese merchants do not intend that their new found trade shall be lost, and with the assistance of the Government are making strenuous efforts to retain their place, and to remove any stigma of inferiority which, rightly or wrongly, may be placed upon their goods by foreign purchasers. In Australia, for instance, it is reported that the Japanese consul-general reports all complaints received direct to his Government, which in turn traces the defective product to the factory in which it was produced. In some cases, the consul actually guarantees on behalf of his Government the quality of the merchandise.

This would appear to be a very good foundation of a successful trade. Some reports have it that all American firms do not place quality first.

Tractor Rating

THOSE favoring a revision of the existing tractor rating formula for belt and drawbar should not overlook the reason for a revision which seems to lie in the present chaos in the minds of the farmer and the dealer, brought about by over-rating of tractors and misleading conclusions as the result of manufacturers' ratings. As an outcome of this, one state has legislated that its university would conduct practical tests and give ratings before tractors can be sold within its confines. Other states are taking different action.

If it is these conditions which have brought about the present agitation for a revision of the rating formula, the new rating should at least correct present abuses and clarify the situation for the farmer and the dealer. The new rating will unquestionably be used as a merchandising argument. It will carry a stamp of official recognition and, as such, it must represent the power capacity of the tractor and should take into recognition superiority of design and construction.

The old rating, known as the S. A. E. rating, which rates a tractor at 80 per cent of its drawbar performance on a 2-hour test, and 80 per cent of its belt performance on a 2-hour test, should be satisfactory. The trouble is that it has not been lived up to. There is no camouflage in it. The tractor must perform and, following this formula, there is little danger of over-rating.

A proposed formula bases the belt rating on the piston displacement of the tractor in connection with the r.p.m. and a constant 13,000. This has all of the earmarks of rating a tractor on a dimension basis. Piston displacement is merely a product of the cylinder dimensions. It has been known for years that the product of an engine in horsepower is not merely dependent upon cylinder dimensions.

The development of internal combustion engines in the last 8 years has been along the line of higher efficiency as a means of increasing power, rather than increasing dimensions and hoping for an increase in power. Many engines have had their power vary without adding to the cylinder dimensions. In an internal combustion engine, power is the commodity to be purchased and not cylinder dimensions or weight. The formula to be used as a criterion of power in merchandising a tractor should then primarily have regard for the power output rather than merely the displacement of the engine. The proposed rating gives the impression of rating on a tonnage basis rather than on a performance basis.

The possibilities for sales reception with such a rating seem dangerously broad. With three engines of the same dimensions, there will be a different performance in each. Good design, careful workmanship, accurate inspection, and good materials, will give power in one engine. In another, the lack of these will result in loss of power. All three, however, will be able to be presented to the farmer as equally efficient engines. The ratings will be the same. Here lies the merchandising danger. On the face of it, such a formula makes an imperfect rating the dominant official factor in a sale. Such a rating begins in a fallacy and ends in confusion. The fallacy is that while purporting to give a statement regarding horsepower, you do not in reality give the horsepower. The confusion is that the consumer has no assurance from the dimension argument that he is getting the horsepower he thinks he is.

With this being the case, how can such a proposed rating correct the existing evil of uncertainty in the minds of the consumer and the merchandiser? It seems to be but another example of shifting the issue. There seems a special danger at this time of establishing such a rating in that we are unquestionably on the verge of developments in internal combustion engines that will give the greater return on the fuel expenditure and a mere dimension rating would not take anything like due consideration of such. It would seem to be merely befogging the tractor confusion to change the present rating and adopt the proposed one.

There is only one way to measure horsepower, which is the commodity for sale, and that is by an engine test, as proposed in the existing S. A. E. rating. It is difficult to see any legitimate reason why any manufacturer should object to a rating based on the actual ability of the vehicle to perform. With horsepower the commodity the farmer wants, let us get a rating that will give him a criterion of horsepower.

Emigration and Machinery

MACHINERY, which will take the place of human hands in performing arduous work, must be developed to a state far beyond what it has now reached. The demand for this machinery is becoming greater every day. The increasing rate of emigration taking away from these shores thousands of the foreign-born who were willing to man the pick and shovel is going to make it necessary to use machines for operations far smaller than they would have been used upon a year ago.

The loading time of the motor truck is so important to its economical operation that contractors and fleet owners are watching this development very closely. When a machine cuts loading time from 20 minutes to 2 minutes, it may be instrumental in saving thousands of dollars on one job. In fact in the excavation in Detroit for the U. S. Base Hospital No. 36, machine loading saved $15,000 on the excavating work, and this was during wet weather. The saving of labor is even more significant.

Latest News of the

Court Limits Picketing of Overland Plant

Defines It as "Act of Aggression" in Important Opinion Granting Injunction—Plant Opens Again

TOLEDO, June 9—Aided by an important court decision against picketing the Willys-Overland Co. will attempt to operate again this week. Vice-president and general manager Clarence A. Earl said to-day the gates would open to workers Thursday and if unable to do so at that time, they would open Monday at the latest.

Federal Judge Killits has limited the number of pickets to be on duty when the plant opens to 150, not more than 50 to be on duty at one time and a maximum of six to be stationed at a gate. The judge ordered that in event of disorder, attributable to pickets, the privilege of picketing be abolished. Picketing is to be permitted from 6 a.m. to 6 p. m., and a deputy U. S. Marshal is to be on duty at each gate to superintend. All gates used by workers, excepting 12, are ordered sealed.

The pickets are required to wear large badges. Only citizens are to be used as pickets. They are not to be stationed within six feet of the gate. The injunction becomes effective at 2 p. m. Tuesday and runs until 10 a. m. June 19.

The opinion is a sweeping one and sets a precedent which other courts may follow in similar strike cases. It brands picketing as an act of aggression and takes a definite stand against it.

The Electric Auto-Lite Corp., Toledo, opened Wednesday, operating under an injunction issued by the United States Court last Friday, which limits picketing.

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DUNLOP OFFICIALS HERE

NEW YORK, June 10—George du Cros, J. V. Worthington and F. C. Baisley, directors and executives of the Dunlop Rubber Co., England, are in this city. They are here to study conditions in the automotive and tire industries.

Various rumors now circulating in regard to their plans are not to be taken too seriously, they state. The results of their investigations will be made known in due course in AUTOMOTIVE INDUSTRIES.

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MAXWELL-CHALMERS MERGED

NEW YORK, June 12—The completion of the consolidation of the Maxwell-Chalmers plants awaits the action of the directors of these two companies. Meanwhile the general plan of the merger has become known. The new company will issue 400,000 shares of stock of no par value, which will be distributed as follows: Maxwell first preferred, 120 per cent; Maxwell second preferred, 60 per cent; Maxwell common, 15 per cent; Chalmers preferred, 90 per cent; Chalmers common, 15 per cent.

An issue of $10,000,000 notes convertible into common stock, will provide for the expansion of the new company. Other details are the subject of negotiations. The Maxwell-Chalmers Corp. has started construction on a $10,000,000 manufacturing plant here. The plant, when in operation, will employ between 15,000 and 20,000 men and will have a capacity of approximately 500 cars a day. The capacity of the present plant is 100 cars.

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A.A.A. Would Modify Federal Road Act

ATLANTIC CITY, June 9—The American Automobile Association, in annual session here to-day, indorsed the Federal Aid Road Act, now pending in Congress, with the suggestion that the act be amended to restrict the aid given from Federal funds to roads that are part of a well defined state system. It was also suggested that the Secretary of Agriculture be given authority to increase the aid given to 75 per cent in certain cases instead of the regular 50-50 plan.

Progress was noted in the plans for unifying taxation laws, anti-thievery measures, effective hand signaling and road beautification.

Mrs. Robert Lee Morrell, a New York attorney, was elected a vice-president. She is the first woman to hold office in the association. David Jameson of Pennsylvania, was re-elected president. Other officers are: Vice-presidents, Ralph W. Smith, Colorado; P. J. Walker, California; H. J. Clark, Minnesota; Clifford Ireland, Illinois; Dr. John H. Quayle, Ohio, and Dr. R. R. Elmore, Kentucky. H. A. Bonnell of New Jersey will begin his twelfth year as treasurer. John N. Brooks of Connecticut is again secretary. A. G. Batchelder holds over as executive chairman.

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WILLS-LEE CANADIAN PLANT

DETROIT, June 12—John R. Lee today said that he and Mr. Wills would build a large automobile plant in Sarnia, Ont. This plant will manufacture their new car and will employ about 2000 men. Sarnia is directly across the river from Port Huron. The Canadian plant thus will be directly opposite the American plant. The Canadian plant will not be started until the American plant is completed.

Detroit Labor Back in Production

Factories Running in Spite of Labor Difficulties—Car Industry Not Affected

DETROIT, June 10.—In spite of a street car strike with all cars idle, the labor situation is improving. The 1500 Studebaker strikers at plant No. 3 are back to work. The issue here was not a matter of wages or hours but one of conditions. The strikers charged discrimination and asked for the reinstatement of certain discharged men. The men were not reinstated.

The strike at the Timken-Detroit Axle Co. is entering its fourth week without sign of adjustment. The men are holding out for increased wages, readjustment of the piece scale system and shorter hours. Production at the plant reached a low ebb but the company is now getting back into operation on a fair scale. This strike has been peaceful. The police are providing the company with plenty of protection.

Ford Workers Help Wadsworth

The Wadsworth Mfg. Co. is still running after six weeks of strike. New men have been taken into the organization to replace those who quit their jobs. During the first three weeks, production of Ford sedan bodies was cut to a minimum but during the last three weeks operation has been resumed in many departments and production is increasing. The Ford Motor Co. sent hundreds of workers into this plant when the strike was called and saved the day for the Wadsworth Co.

The Foundry workers are very restless and a number of strikes in local foundries is hampering parts production. The Detroit Forge Co. workers are on strike. They demand a wage increase and an 8-hr. day.

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ORDNANCE FOR S. A. E.

NEW YORK, June 12—Word has been received from the War Department that 30 carloads of automotive war apparatus have been shipped to Ottawa Beach, Mich., for the summer meeting of the S. A. E. on June 23-28. The material sent includes tanks with and without guns, 8 trucks fitted for various forms of shop work, such as air compressors, power saw, drill press, etc. There are also various sized tractors, up to 10 tons and some French guns. This equipment will be in place for the meeting.

The number of reservations to-day was 608.

Automotive Industries

Slight Prospect of Trade with Europe is Hanch's Report

Secretary of N.A.C.C., After 4 Months Abroad, Has a Gloomy Export View

French Remind Him of Our High Tariff on Their Cars Before War and Now

NEW YORK, June 9—At present there is no indication what will be the attitude of the government of Great Britain toward removing present restrictions on the importation of automobiles after Sept. 1, 1919, is the opinion of C. C. Hanch, secretary of the National Automobile Chamber of Commerce, after his 4-months' investigation of conditions in Great Britain, France and Italy, and after his attending a meeting of the automobile interests of the Allies in Paris, March 5 and 6, 1919. Mr. Hanch's report was read to those present at the N. A. C. C. meeting here.

The automotive manufacturers of Great Britain, France and Italy are insistent upon receiving absolute protection against the United States for a considerable period, say 2 years, and substantial protection thereafter. They naturally have certain influences with their respective governments and unless public opinion intervenes, it is likely that import restrictions will be continued for a considerable period.

According to Mr. Hanch there is a serious shortage of automotive equipment in these European countries and a great demand for motor apparatus, so that the existing restrictions are working hardship on the population.

France takes issue with Mr. Hanch and asserts that the French manufacturers are well able to furnish all the automotive equipment necessary for the French population, and does not take kindly to the requests that French restrictions of importations be removed. They unqualifiedly declare that they cannot subscribe to any such plan for America selling automobiles in France as suggested, and further draw attention to the fact that for practically 10 years America had a 45 per cent ad valorem duty on French cars, while at the same time France was exacting an import duty of from 8 to 10 per cent on American machines.

In the view of France, the treatment by America was hard and unjust and, to-day, it is but natural that the French manufacturers should urge the French government to apply to each of the Allies what those Allies think proper to apply to France. In a word, this means that if America applies a 45 per cent ad valorem duty on French products, then the French government should apply a similar duty on American products.

The whole question was discussed at the conference in Paris, March 5, by representatives of the automobile industry from England, France, Belgium, Italy and the United States, reports of which have already been published in AUTOMOTIVE INDUSTRIES.

Mr. Hanch, in his report to the N. A. C. C., says that he pointed out the injustice of import restrictions in a letter to the secretary of the French organization known as the Chamber Syndicate des Constructeurs d'Automobile. Fully 20 per cent of Mr. Hanch's report is taken up with his letter and the French reply and, from the latter, it is quite evident that the French do not coincide with the views expressed by Mr. Hanch as representing the N. A. C. C.

There was another conference held after March 5 in which French manufacturers expressed a slight change in opinion and indicated that they would not advocate a continuance of the embargoes after July, 1919. It might be inserted here that since Mr. Hanch left Paris the French automobile manufacturers have recommended that, after the signing of Peace, France will adopt a duty of 45 per cent on American automobiles until January, 1920, and after that date the duty will be 15 per cent.

Favors Removal of Restrictions

Mr. Hanch, in his letter to the Chambre Syndicale des Constructeurs d'Automobile, talked in favor of France removing restrictions because of the general shortage of automobiles in France, the inability of the French manufacturer to meet the demand and the strong demand on the part of the French industry for automobiles. He summed his conclusions under the following heads:

1—There is a material shortage of transportation traction equipment for civilian use in all European allied countries.

2—The European manufacturer cannot supply the required amount of automotive equipment needed by the civilian population as soon as it should be provided to permit the economical welfare of European allied nations.

3—The manufacturers of the United States are in position to furnish a part of the automotive equipment needed by the civilian population of the European allied countries.

4—The needs of the civilian population of European allied countries will absorb the production of European manufacturers as well as equipment which can be furnished by the U. S. A.

5—Further delay in granting import licenses, or in removing embargoes, can only result in serious injustice to the European allied countries by preventing such population from securing its requirements as soon as needed and also by encouraging extortionate prices for second hand and other equipment.

6—The earlier the trade relations between all the allied and friendly nations are established the sooner will be the return to normal and economic conditions in all the countries.

7—The early removal of embargo and the granting of import and export licenses is in the best interests of all nations concerned.

That the French Chambre Syndicale des Constructeurs d'Automobile quite seriously objected to being told by Mr. Hanch what was best for the French civilian population and what were the requirements, is indicated by the letter written by H. Cezanne, general secretary of the Chambre. The latter was couched in the typical French language which has suffered considerably in translation, but still indicates how very much France resented dictation from America as to what she should do for her own people.

Undoubtedly France thought of the days when America put a 45 per cent duty against her products, and has retained it practically up to the present time, and wondered why America, who

(*Continued on page* 1371)

Rubber Imports Slow Up in May

16,348 Tons Come in, Compared With 27,948 Last Month

NEW YORK, June 11—Imports of crude rubber into the United States in May were only 60 tons ahead of the amount imported in the same month last year, a drop of 11,600 tons from last month's figures.

Comparative figures for the past four years, as compiled by the Rubber Association of America, follows:

	1919 Tons	1918 Tons	1917 Tons	1916 Tons
January	7,235	16,084	12,788	9,162
February	14,079	13,108	10,162	1,597
March	28,223	17,161	18,624	10,070
April	27,948	13,425	13,000	10,014
May	16,348	16,288	18,411	11,189

War Work Considered in Show Allotments

N.A.C.C. Permits Manufacturers to Enter Production for 1919, 1918 or 1917

NEW YORK, June 11—War work was recognized in the drawing of spaces for the coming national automobile shows by the National Automobile Chamber of Commerce at the meeting held here last week. It was decided that the spaces should be allotted on the factory production for any of the three last fiscal years ending June 30. In other words, the manufacturer may elect whether he will enter his production for the year ending June 30, 1919, 1918 or 1917.

The shows, as stated last week, will be held in New York at the Grand Central Palace, Jan. 3 to 10, and in the Coliseum in Chicago on Jan. 24 to 31. Coincident truck shows will be held in both cities. The site of the New York truck show probably will be in the Twenty-Second Engineers Armory at 168th Street and Broadway. The Chicago truck show will be held in the Drexel Pavilion in the Stock Yards district.

Two special sessions of future possibilities were held in connection with the meeting of the N. A. C. C. One was the meeting with the representatives of the oil trade on Thursday night. At this meeting it was learned that the automotive manufacturers and the oil-men have been working without the mutual understanding that would be exceedingly helpful to both. Especially was the forecast for truck production in 1919 as presented there a surprise to the oil-men.

Export Managers Hear Hanch

The second special session of interest was that of the export managers. They heard a report from C. C. Hanch, who has been studying conditions in Europe for six months past. In addition to his formal report, Mr. Hanch was kept on the floor for two hours answering questions. Preparations were made for special investigations of three developments from this discussion, which probably will have a direct bearing on the future trade. It was voted to broaden the foreign trade department of the Chamber. The showing was that the export now is $125,000,000 of the total $1,300,000,000 automotive business.

A constitutional movement to increase the number of directors of the Chamber from 15 to 18 members was originated.

The following directors were re-elected: John N. Willys (Overland), H. H. Rice (Chevrolet), Roy D. Chapin (Hudson), C. C. Hanch (Studebaker), and J. Walter Drake (Hupmobile). At the next meeting a constitutional amendment to increase the directorate from 15 to 18 members will be offered to provide for further representatives of the truck industry. At present there are five members of the truck industry on the board of directors.

THE FUEL CONFERENCE

NEW YORK CITY, June 10—A so-called cabinet for the consideration of fuel problems was a result of the meeting Thursday night of representatives of the automobile industry and the petroleum industry to consider what should be done for the general good on the fuel situation. This cabinet of ten is expected to outline the fuel problem and to guide the united efforts of the fuel people and the apparatus manufacturers in the right direction. This objective is to give a better fuel, and improvement, perhaps, in apparatus to handle the fuel, as engines and vaporizers.

There was no dissenting view expressed by either side on the subject. Both are united in their purpose to work together to this end. With many of the oil-men, there seems to be no fuel problem and some of them are apparently ignorant of the difficulties of properly handling fuels on the market.

From an oil-man's point of view the increased output of fuel is merely one of a broader use of the cracking process, which is gaining all the time, as well as the sinking of more wells. It seems impossible to produce a better fuel than we have to-day and produce it in the same quantities from a given amount of crude. If we want to increase the fuel, we will have to lower the standard. If we want to increase the quality it will be necessary to lower the volume.

At present the fuel interests are well over-stocked with fuel oil and some of the refineries are closed down temporarily on this account. The dropping off in war demand has been the cause of this.

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PRICES OF ARMY TRUCKS

WASHINGTON, June 9—The Sales Division of the War Department, following its recent conference with the trade press and the industry with regard to the sale of surplus motor vehicles, is now fixing the prices and will soon catalog them and send the catalog to the various district offices of the War Department.

The trucks will be sold either by auction for cash, or to the highest bidder on sealed proposals on due public notice, or at the current market price or by negotiations under competitive conditions, providing the price obtained is not less than that fixed by appraisal or is the highest of not less than three independent competitive bids. The supply and condition will decide the methods chosen.

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WINTHER EXPANSION PLANS

KENOSHA, WIS., June 9—The Winther Motor Truck Co., at a special meeting of the board of directors, June 11, will vote on the plan to issue $1,000,000 of common stock, most of which will be taken by present holders. The proceeds will be used to increase the facilities and otherwise finance expansion. The present plant was erected a few months ago at a cost of $150,000 and a second unit of equal size is proposed.

Paris Show Will Be October 9-19

Space Requirements Will Place Decided Handicap on American Exhibitors

PARIS, May 22—Oct. 9 to 19 inclusive have been fixed as the dates for the 15th French automobile show, which will be held in the Grand Palais in Paris after a lapse of 4 years. This is the first automobile show to be held in Europe since the war and will inaugurate the series that will include London and Brussels.

American exhibitors are at a disadvantage compared with European competitors. One of the rules states that allied manufacturers can be admitted on the same footing as French makers, providing they have taken part in at least three previous Paris shows, and also providing that the import duties in their own country prior to 1914 were not higher than 15 per cent ad valorem. As the United States is the only country in the world having a duty higher than 15 per cent, it is evident that this rule has been adopted entirely with the object of handicapping American exhibitors.

The regulations state that foreign exhibitors who do not comply with these requirements will be given special spots decided on by the committee. This practically means that they will have to take whatever spot may be available after everybody else has made a selection.

When the war broke out in 1914, numerous firms had made a request for space and had, in many instances, deposited the entry fees for the 1914 show. These firms will receive preferential treatment when space is allotted.

No enemy firm can exhibit at the Paris show.

Stands will be uniformly decorated and will be delivered completely equipped with signs, carpets, etc., ready for receiving the actual exhibits. As in previous years, a refund will be made to all exhibitors after expenses have been paid.

The Grand Palais, which is the biggest hall under one roof in Europe, if not in the world, has been occupied by the military during the war. It has just been released and is being repaired and equipped with the show in view. There is no doubt that every inch of space will be occupied. The president of the Show Committee is Baron Petiet, president of the French Society of Automobile Manufacturers. Henri Cézanne is the general manager of the show.

American manufacturers desiring space are recommended to apply without delay to 51 rue Pergolèse, Paris.

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DETROITER CREDITORS TO MEET

DETROIT, June 9—Creditors of the Detroiter Motor Car Co. will hold a final meeting at 117 Fort Street, west, on June 25 to pass on the trustees' report showing property for distribution, etc., and offer for sale the balance of unpaid accounts receivable.

Italian Factories on 8-Hour Schedule

Experiment of No Lunch Hour Fails—Strike of Foremen Serious

TURIN, ITALY, May 20—All Italian automobile factories have been on an 8-hr. day basis since March. The attempt has been made to run a single shift of 8 hours without stop for meals. This is still being done at the Fiat factory, but it is recognized that the experiment is a failure. The seventh and eighth hours are not productive, and after working for that length of time it is impossible for the men to do overtime.

In consequence Fiat will shortly change to four hours in the morning, two hours for the mid-day meal, and four hours in the afternoon.

The Lancia factory also adopted the 8-hr. day without a break, but has changed over to 8 to 12 and 2 to 6. The reduction from 10 to 8 working hours a day has been made without any diminution in the weekly wage. On piece work an increase of 25 per cent has been granted.

A strike which affected all Italian automobile factories has just been brought to a close after one month's duration. The foremen and heads of departments, being dissatisfied with working conditions, left the shops. An attempt was made to run without these men, but it was not successful, and practically all the shops had to close.

Although an agreement was arrived at after 31 days, it is reported that the interruption has thrown the factories back at least two months.

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IN FRENCH TIRE FACTORIES

PARIS, May 20—The 8-hr. day has been permanently adopted in the French factory of the Goodrich Tire and Rubber Co. at Colombes, near Paris. Owing to the shortage of coal, the work hours had been reduced on many occasions and, when the Government law was proposed, it was decided to make the 8-hr. day a regular feature.

Arthur Lumsden, the director of the French Goodrich company, has adopted the plan inaugurated a few months ago by the neighboring Gnome & Rhone Co. of having a break of only half an hour in the middle of the day for a meal. To do this it has been necessary to erect dining rooms, as the French laws forbids eating in a building where work is carried on.

While the 8-hr. day is well received by French workmen, the objection is being raised by their wives that the men have too much time on their hands and consequently spend too much money for drink.

There is no doubt that the drop in France from 60 to 48 hours a week will raise social problems in which employers of labor must take an interest. When working 60 hours a week, a man's time was fully occupied in working, sleeping and eating. The French working man had few hobbies. Now that spare time has been thrown on his hands, there is danger of his misusing it, if not educated to better ways.

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ITALIAN EXPORTS

TURIN, ITALY, May 10—Italy exported 1867 trucks and 1071 passenger cars, having a nominal value of $9,068,500, during the year 1918.

This is a considerable drop on the two preceding years, for in 1917 the number was 8734 with a value of $22,995,761, and in 1916 it was 6463 trucks and passenger cars valued at $16,806,450.

The decrease is due to the cancellation of army contracts. In 1916 and 1917 Fiat alone was building from 60 to 100 trucks a day, 50 per cent of them going abroad. This was cut down by about three-quarters when the armistice was announced.

The number and value of exported passenger cars has increased, being 1071 in 1918, compared with 702 in 1917 and 824 during 1916. Although only two out of the twelve months of 1918 were under partial peace conditions, the returns indicate that Italy's greatest activity will be in passenger cars rather than in trucks.

Automobile imports were lower during 1918, only 50 trucks and 30 passenger cars, valued at $161,820, being brought into Italy.

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PROGRAM FOR MECHANICAL ENGINEERS

DETROIT, June 10—The spring meeting of the American Society of Mechanical Engineers, to be held here June 16-19, will have at least 22 papers, according to the present schedule. The first session will be largely taken up by the regular society business.

Of particular interest to the automotive industry is the gas power session, which will consider the internal combustion field, including the Deisel and other types of oil engines, and the kerosene engine. Carburetion will also be taken up during this session. Another session will be on fuel economy, which includes papers on pulverized coal and fuel oil.

Industrial relations will be treated by at least three speakers and probably others will be announced. This session will be on Tuesday afternoon.

The production of Liberty engine parts at the Ford plant will be treated by W. F. Verner on Wednesday morning.

A paper, "Crude-Oil Motors vs. Steam Engines in Marine Practice," by J. W. Morton, one by D. L. Arnold, entitled "A Suggested Formula for Rating Kerosene Engines," and "Standards of Carbureter Performance," by O. C. Berry will be presented.

Airplane subjects will be given attention on Thursday, when there will be a paper entitled "Elements of a General Theory on Wing Design," by Walter C. Durfee, also "Air Fans for Driving Electric Generators on Airplanes," by Captain G. Francis Gray, Lieut. John W. Reed and P. N. Elderkin.

Used Cars at Premium in Italy

Manufacturers There Putting Export Trade First, While Imports are Barred

TURIN, ITALY, May 20—There is a very strong demand throughout Italy for both trucks and touring cars. The factories are unable to meet local requirements, with the result that used cars are bringing fancy prices. The army has not offered any of its cars for sale, thus tending to maintain the artificial price of used cars.

The home manufacturers have nothing to fear, for automobile imports are prohibited. Indeed, in many cases Italian manufacturers are more interested in exporting, in an effort to establish foreign markets, than in meeting the requirements of their clients at home.

The result of this is that there is sharp competition for any used cars which may be put on the market, and in most cases used cars are sold considerably in excess of the prices asked by the factories for new models. As an example, a used Fiat 3½-ton truck can be sold for more than the Fiat Co. price for a new truck. Four-year-old Lancia cars are bringing as high as $12,000 at nominal rate of exchange.

It is certain that the army is making a mistake in not placing its surplus trucks and cars on the market while the demand is great and the supply small. Within six months the factories will be producing in large quantities and the bottom will drop out of the second-hand car market.

Lancia has decided to continue his 4-cylinder 30-hp. model produced before the war. The only material change is the adoption of the detachable cylinder head. This change has become general in Italy, for it has been taken up by Fiat, the biggest producer, and also by Nazzaro, who is now preparing to build a high-class four with detachable head and valves in the head.

Nazzaro has abandoned his original factory at Turin and is taking over the new works at Florence.

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ARMSTRONG-SIDDELEY NEW CAR

COVENTRY, ENGLAND, May 27—The Siddeley-Deasy Motor Car Co., Ltd., will soon be known as the Armstrong-Siddeley Co., Ltd., and the car to be manufactured, as the Armstrong-Siddeley.

The new Armstrong-Siddeley car will use a six-cylinder engine, with overhead valves, in which aluminum construction will figure prominently. The cylinders will be 3½ x 5¼. Features to be incorporated are spiral bevel axle drive, cantilever springs, disk wheels and electric starting and lighting. Deliveries will begin in August. The price will be $3,300. The entire manufacturing efforts of the company will be concentrated on one model.

English Manufacturer Slow in Production

Labor Troubles Blamed for Inactivity — Importers Want Duty Removed

LONDON, ENGLAND, May 28—One cannot help but be amazed at the slowness with which the British manufacturer is returning to normal business. Practically 50 per cent of the car makers have not yet delivered a single car to the public, and there are scarcely more than four firms that are producing 50 per cent of their pre-war output. The invariable excuse for the delay is labor troubles.

British importers of American cars take the view that the only hope for the British automobile industry lies in the removal of the present prohibition. If the restrictions on imports were removed, the British makers would then have to make a determined effort for the business and would put up what is described as a real sporting fight.

By Sept. 1, British manufacturers will have had 9 months in which to clean up after the war, and prepare to meet any competition, but the sentiment is growing that restriction of import may be continued after this date, and some take the view that there may be an increase in restrictions. At present it is almost impossible to get any united thought on the subject. The view is held that it will be necessary to have another general election in the near future at which time the whole subject will come up for review as a national issue.

There is beginning to be heard in England an outcry against the introduction of a tariff under the government administration without having the direct sanction of it from the voters.

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LONDON, ENGLAND, May 28—The difficulty of British manufacturers to get under way with production is accentuated by the uncertainty with regard to the price of coal. This is having a serious effect upon the industry. It is difficult to secure close prices for material. While there is a great deal of restless talk among labor, manufacturers generally agree that these will smooth out as time passes.

Some factories under the 47-hour a week schedule which began Jan. 1 are turning out as much as they used to in the 53-hour week, with the same number of workers. There are others who are having considerable difficulty under the shorter week, and at certain establishments workers have refused to work on a piece basis and are working slower on the hour basis. Recently the wood working trade union forbade any piece work system in the future for its members. There are some factories in which this order is not being observed.

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TRUCK DEMAND HEAVY

LONDON, ENGLAND, May 28—The demand for motor trucks is so far in excess of the supply that deliveries in 8 weeks is the best that can be had for any standard British make of trucks.

This delay in delivery is all the more important because the government is not handling the disposal of war trucks as was hoped it would. Officials in charge of selling war trucks seemed more desirous of getting high prices for individual trucks than speeding sales and getting rid of the war supply. Although there are 20,000 trucks supposed to be ready for sale, many of them new, only 500 or 600 per month are being released for public sale to consumers. Some of the dealers are endeavoring to buy from the government trucks of the make they handle, but it has not been possible to do so.

In the meantime there are many automobile parks where thousands of trucks can be seen half buried in mud without means of protection, and at the same time prospective owners cannot make purchases.

This needless delay is largely due to the fact that the government is tied up with peace negotiations, and those in charge do not seem to have the business vision that the situation calls for.

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OPPOSES EUROPEAN BRANCHES

NEW YORK, June 12—C. C. Hanch, who inspected the automobile industries in Great Britain, France and Italy as a representative of the N. A. C. C., is not much in favor of American automotive manufacturers establishing branches in Europe at present.

They would have no advantage because import restrictions and high custom duties apply to parts of vehicles, as well as to completed vehicles.

It would be some time before American manufacturers could install the necessary manufacturing equipment in Europe to go on a production basis, and by the time such factories were established, import restrictions would be removed and custom duties modified, so that exporting of the completed vehicle from America would be more desirable than the assembly of it in Europe. At present labor conditions in Europe are also unsatisfactory.

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War Department Surplus Vehicles Transferred

WASHINGTON, June 12—The Director of Sales of the War Department this morning approved the transfer of the entire surplus of serviceable motor vehicles held by that Department to other Government departments, a total of 39,100 vehicles. This action leaves fewer than 1000 vehicles to be sold at public auctions. These are unserviceable because of design or for other reason, and will be available only for parts or junk.

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FORD STEEL ORDER

NEW YORK, June 12—An order for 150,000 tons of steel, with a possibility of an increase of 200,000 tons, by the Ford Motor Co. is announced by the U. S. Steel Corp.

"Liberty Fuel" Soon to Have Real Test

One of Originators of Much Disputed Compound Says It Will Be Put on Market

CHICAGO, June 7—Liberty fuel, the special motor and airplane product developed by the Government for its war trucks and planes, and regarding which conflicting reports came from Washington early in the winter, is to be put on the market in large quantities within a short time, according to former Major Zimmerman, who was instrumental in its development. Zimmerman made this statement in enlarging upon his theory that one of the greatest developments of the future in the automotive field would be the chemical treatment of fuels to increase their volatility and reduce the heat losses through cooling and exhaust.

The announcement of the marketing of Liberty fuel came in a discussion of a paper on "The Design of Intake Manifolds for the Present Heavy Fuels" by F. C. Mock, engineer of the Stromberg Motor Devices Co., presented at the June meeting of the Midwest Section, Society of Automotive Engineers, last night. In answer to a question as to conflicting reports of the value of Liberty fuel, Zimmerman said that road tests covering thousands of miles were made and that no undesirable features were shown. The varied reports, he said, were directly due to war conditions in Washington.

In his paper on intake manifold design Mr. Mock discussed the necessities for proper carburetion, particularly the shape and heating of the manifold. He definitely advised against any attempt to heat the fuel in the float bowl of the carbureter, because in many sections of the country there are fuels which contain a percentage of very volatile elements, casing head gasoline being a sample. He gave it as his belief and hope that the time is coming when the service departments of each responsible motor car and motor truck manufacturer will develop fittings and connections of this nature to replace the equipment of cars now in service. After the patterns and tools are once made the cost of production is low, and the application could probably be made in half a day, so that the complete installation should not cost over $10 or $15.

Mr. Mock's paper will be printed in a future issue of Automotive Industries.

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COMPLAINT AGAINST PREST-O-LITE

WASHINGTON, June 10—A complaint alleging that exclusive contracts made by the Prest-O-Lite Co., Indianapolis, are in violation of the Clayton anti-trust act has been issued by the Federal Trade Commission. Deposits required for the use of steel gas containers are the basis of the complaint. The company is cited to appear July 24.

Ships, Investments, Parcel Post at Pan-American Conference

Latin American Countries Anxious for Better Shipping Facilities with U. S.—Protection of Trademarks Necessary—Press Relations

WASHINGTON, June 9—The immediate establishment of ample freight, mail, and passenger steamship facilities between North and South America, the necessity of investing American capital in South America, the elimination of unnecessary restrictions on parcel post shipments and the need for a well-defined program for the protection of patents, trademarks and copyrights in Latin America were the principal developments of the Pan American Convention which closed here last Friday following a 5-day meeting attended by more than 700 delegates.

The Latin American representatives were particularly pleased with the announcement by Edward N. Hurley of the U. S. Shipping Board, which told of the proposed establishment of great fleets of vessels between the U. S. and the southern continent. They stated that this is the most important requirement of the Latin American countries, and that the development of better shipping and mail carrying facilities will insure an expansion of the trade between the two continents.

Parcel Post

The need of new treaties between the U. S. and the Latin American countries providing for removal of restrictions and regulations on parcel post was mentioned by several speakers, including Frutos Plaza of Montgomery Ward & Co., who praised the increasing efficiency of the parcel post between the U. S. and Latin America, but decried the regulations existing in Brazil and Argentine, which prescribed the use of customs brokers whose fees make the employment of the parcel post practically impossible.

Mr. Plaza told also that the delivery by parcel post in South America had improved remarkably in the past few years, and cited as an instance a shipment made by his company of 300 parcels to Bolivia, each under 11 lb. in weight to conform to the legal limits, and each of which arrived safely and promptly to its destination in the interior of the country.

The necessity for protecting trademarks was illustrated by the examples of the Hupmobile, Renault, Pierce-Arrow, Fordson, and other well-known American trademarks, which have been registered or applied for by natives or European concerns, and which are consequently lost to the American owners. The countries of Latin America, it was said, have furnished a particularly profitable field for the registration of trademarks by others than their originators for speculative purposes, and nearly every issue of the official bulletins of these countries contains applications for trademark registration that are fraudulent or at least unauthorized.

Manufacturers were urged to register their trademarks promptly. The cost of registration was stated to be about $6 per country, per year. There have been no lawsuits conducted in any of the Latin American countries, they were warned, to recover a mark that has been stolen in which the cost has been less than the cost of registration in all of the countries in the southern continent combined.

Press Relations

The establishment of better press relations was predicted by Frank B. Noyes, president of the Associated Press, who told of recent arrangements just completed whereby the largest South American newspapers will for the first time in history take the Associated Press service. This, he stated, should insure a better understanding of the habits and businesses between the two countries. More than 18,000 miles of cables have been installed between New York and Latin America, according to John L. Merrill, president of the All America Cables, who cited this as another connecting link between the continents.

South American papers, it was stated, have been subscribing to the European press for news service and for this reason have been influenced against American products and in favor of European commodities. Robert Barrett of the Bureau of Foreign and Domestic Commerce described the operation of the new press service between the U. S. and South America, stating that 3500 words a day are being sent over the cables, and also praised the branch of the Committee on Public Information, which was established in Buenos Aires during the war, and which he stated contributed three or four columns daily to the local newspapers, doing more than any other agency to acquaint the people with the progress of the U. S.

In answer to the question, "Will the U. S. hold its export trade gained in Argentine during the war?" Mr. Barrett said that it will hold a great part of the business, but that we can not expect much business from Argentine for the balance of this year.

Immediately after the armistice, he said, American manufacturers, who had been holding up orders to Argentine for many months, began to ship commodities to that country, with the result that a surplus of supplies has been received there. He praised the establishment of the two American branch banks in Buenos Aires which now allow American manufacturers to extend credits as freely as European competitors. He described the banks as being very successful with deposits over $60,000,000.

Eighty-eight American firms, he said, are carrying stock in Buenos Aires and are consequently in a position to meet any and all European competition. His statement that the Argentine Republic now regards the U. S. in a more friendly light than any other nation was repeated by a number of Argentinian representatives, all of whom attributed this feeling to the motion picture business, which they stated has shown the American progress and ideals to Argentine.

The aid being given to industry by the business press of the U. S. was discussed by A. C. Pearson, president of the Associated Business Papers, who stated that the Webb-Pomerene bill, which "promises so much for foreign trade in the United States," was made possible largely by the co-operation of the business papers.

The business publications, he said, inform their readers of possible markets, of all trade news, of new designs, of the progress of the industries, and extend important advice and criticism, besides also functioning as important encyclopedias of knowledge through their advertising columns.

Capital Investments

Other discussions, including those by Charles M. Schwab, Frank A. Vanderlip, Senor Augusto Villaneuva of Santiago, and Senor Julio Zamora, Financial Agent of the Bolivian Government, told of the need for re-organization of Pan American business and of the duty of the U. S. to invest capital in Latin America to further the industrial and commercial relations between the two nations and to provide funds whereby the Latin American countries can pay for their exports from this country.

Other subjects discussed included the necessity of teaching Spanish in the schools of the U. S., the development of transportation in Latin America, the extension of better credit facilities to Latin American buyers, the improvement of the administration of consular offices and the revision of tariffs.

The next meeting of the Pan American Conference will be held in January, 1920, according to notice received from President Wilson during the last Convention.

CURTISS BUYS SERVICE PLANES

WASHINGTON, June 6—The Air Service has sold to the Curtiss Aeroplane & Motor Corp. 1615 JN-4D airplanes without engines, and 1100 Standard J1 planes without engines, for $2,272,000, which is 12 per cent of the original value, which was estimated at $22,500,000. The Air Service discontinued the use of the SJ-1 plane last summer.

TILTON BELT REPRESENTED BY CASSIDY

NEW YORK, June 11—Edward A. Cassidy Co., Inc., has been appointed manufacturer's representative and will act as the sales department for Tilton endless woven belt.

Air Service Seeks Inventions

Gasoline Gages and Tanks, Portable Hangars Among Devices Needed

WASHINGTON, June 7—The War Department Air Service is in need of certain devices and appliances and asks the assistance of inventors and engineers with regard to development of the following:

Gasoline tanks that will withstand a salvo of 15 shots fired at a range of 30 yd., the ammunition consisting of calibre 30, equally mixed, service, tracer, incendiary and armor piercing bullets, fired through the tank at the most vulnerable angle with fire occurring in 10 consecutive tests on as many tanks. The weight should be kept low and be not more than 75 per cent more than the usual standard weight tank. Information about previous experiments will be furnished if wanted. Air bag floats, landing skids, etc., are wanted to prevent a machine from capsizing when landing in water.

Portable hangars for field service as the present hangars made of canvas are unsatisfactory and leak and blow down. Hangars are wanted to hold at least four De Haviland planes with enough room in addition for mechanical work, and should incorporate necessary wiring for electric lighting and extension lamps.

Gasoline supply gages are wanted that are responsive, serviceable and accurate to the last half-gallon, with mounting on the tank.

Central electric power plant, a single generator and battery is sought that will furnish required power for the radio installation, heating and lighting, electric starter, ignition and the motor driven camera. This is also to include necessary transformers to supply these various apparati with the electrical energy needed in proportion and kind.

Some sort of engine driven plant is wanted so that the head resistance of the wind driven generators now used will be eliminated. A saving in weight is expected from the new type suggested. The plant is wanted for use on Liberty 12 and Hispano Suiza 300 engines.

Mobile cranking device to be mounted on a motor truck to be electrically driven and for use on planes not equipped with self starters, is desired, so it may be used at an aerodrome by being backed up on to the front end of any airplane and built with a flexible arm attached to the propeller. The electrical energy is then to be used to crank the engine and start it. When the engine picks up, the arrangement should be such that the device will be automatically thrown out of connection with the propeller.

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FORSCHLER UNDER NEW COMPANY

NEW ORLEANS, May 19—Philip Forschler Wagon & Mfg. Co. has been bought by the Forschler Motor Truck Mfg. Co., Inc., with headquarters at 120 North Claiborne Avenue.

34 PER CENT OF AIR ENGINES AMERICAN BUILT

WASHINGTON, June 6—The A. E. F. Air Service received 10,464 airplane engines during the war and up to Nov. 30, 1918, of which 4153 were Liberty 12's. The Allies produced 6944 or 66 per cent of the total number, and the United States 3520 or 34 per cent.

Of the 2698 planes received at the front by the A. E. F. the Allies produced 75 per cent, France turning out 1825, England 206 and the United States 667.

Five hundred and nine American fliers lost their lives in action including training and accident casualties, as compared with 2680 British and 1945 French. Following is the table:

	Killed	*Wounded*	*Missing*	*Per Cent Killed*	*Per Cent Wounded*	*Per Cent Missing*
American	509	241	277	50	23	27
British	2,680	2,988	1,837	36	40	24
French	1,945	2,922	1,461	31	46	23
Total	5,134	6,151	3,575	35	41	24

From the beginning of the war to April 30, 1919, the Air Service condemned 1105 planes and 853 engines of all types as follows:

Primary training		*Advanced training*		*Service*	
Planes	861	Planes	211	Planes	33
Engines	713	Engines	129	Engines	11

Ten thousand five hundred and ninety-four service engines and 2457 service planes are included in the "active" class by the Air Service, which has inventoried its equipment, as against 10,636 obsolescent training engines and 2955 training planes, and 2540 obsolete engines and 2031 planes. Following is the complete inventory showing the active engines and planes which are considered worthy of use, the obsolescent which are used but will not be rebuilt or repaired when worn, and the obsolete which are no longer used:

Active	New	Used, but in flying condition	Out of commission	Total	Per Cent New	Per Cent Used, in commission	Per Cent Out of commission
Service engines	10,081	288	225	10,594	95	3	2
Service planes	2,127	167	163	2,457	86	7	7
Training engines	2,007	608	122	2,737	73	22	5
Training planes	773	980	488	2,241	35	44	22
Obsolescent							
Training engines	4,480	3,942	2,214	10,636	42	37	21
Training planes	539	1,804	612	2,955	18	61	21
Obsolete							
Engines	1,419	158	963	2,540	56	6	38
Planes	1,026	65	940	2,031	51	3	46

	Killed	Wounded	Missing	Per Cent Killed	Per Cent Wounded	Per Cent Missing
American	509	241	277	50	23	27
British	2,680	2,988	1,837	36	40	24
French	1,945	2,922	1,461	31	46	23
Total	5,134	6,151	3,575	35	41	22

Primary training		Advanced training		Service	
Planes	861	Planes	211	Planes	33
Engines	713	Engines	129	Engines	11

75 PER CENT SAVED ON CANCELLED AIR CONTRACTS

WASHINGTON, June 9—Contracts have been cancelled and suspended for the Air Service since the date of the armistice representing an original value of $130,000,000, liquidated at a saving of $95,000,000 or 75 per cent. The following table gives details of how the various items have been dealt with.

	Value of contracts liquidated	Per cent of suspensions liquidated	Amount saved on liquidation	Per cent saved on liquidation
Balloons and supplies	$4,067,558	42	$3,418,830	84
Airplanes and spares	7,707,455	5	6,152,083	80
Fabrics, lumber and metals	3,984,143	51	3,127,143	78
Engines and parts	102,501,838	38	76,119,701	74
Instruments and accessories	1,449,995	14	1,021,131	70
Chemicals and chemical plants	8,983,419	66	6,242,331	69
Miscellaneous	1,548,547	14	1,281,735	83
Total	$130,242,955	27	$97,361,955	75

PROJECTS FOR 11,350 MILES

WASHINGTON, June 6—Projects for improving highways totaling 11,350 miles to cost $108,295,329, and on which Federal aid amounting to $43,076,176 was requested, have been approved by the Bureau of Public Roads to date. This includes 1188 projects, of which 813 miles have been completed at a cost of $6,870,451, of which $2,692,491 was paid in the form of Federal aid by the Government.

AERIAL SERVICE IN ITALY

WASHINGTON, June 9—A regular air mail service has been started between Rome and Naples, Italy, with two trips daily from each city. An aerial line will be started between Rome and Palermo in the near future. The trip will take about 4 hours. This is one of the first international air routes that will complete a route between Rome and Constantinople.

NEW CONSTITUTION ADOPTED BY GAS ENGINE ASSOCIATION

CHICAGO, June 7—A new constitution for the National Gas Engine Association, which provided for subsidiary groups and for greater specialization in associational work, was adopted this week at its annual meeting here. Sections already formed are the following: Farm Engine Section, T. C. Menges, Associated Manufacturers Co., Waterloo, Ia., chairman; Oil and Stationary Engine Section, O. G. Deane, Muncie Oil Engine Co., Muncie, Ind., chairman; Tractor Engine Section, R. K. Schriber, H. C. Doman Co., Oshkosh, Wis., chairman; Accessory Section, Walter Brown, Webster Electric Co., Racine, Wis., chairman; Farm Light Plant Section, L. S. Kilholtz, Domestic Engineering Co., Dayton, Ohio, chairman.

About 20 farm light concerns were present at the convention and it was decided that instead of forming a separate organization it would affiliate with the Gas Engine association.

Lynn W. Meekins, of the Bureau of Foreign and Domestic Commerce, addressed the last general session on the possibilities of foreign trade. He considers China, Australasia and Siberia as the sections of the world offering the greatest opportunities. He gave the following figures on the shipment of internal combustion engines during the war to June 30, 1918:

Engines for military tractors, 23,500; kerosene engines, 15,000, principally to Canada, England, Australia and New Zealand; gas automobile engines, 35,800, principally to Canada, England and Argentina; korosene stationary engines, 27,000, principally to Canada, Australia England, Cuba and France; gas marine engines, 7,200, principally to Canada, England, British India and New Foundland; gas stationary engines, 3,300, principally to France, Japan, England and Australia.

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LOCOMOBILE SUIT MOTION

NEW YORK, June 10—Attorneys for the National Automobile Chamber of Commerce to-day filed a formal motion that the suit against the Chamber brought by the Locomobile Co. be dismissed because the plaintiff had not stated a sufficient cause of action. This is the friendly suit filed by Locomobile Co. attacking the validity of the patent pooling department conducted through the Chamber. The pleadings allege that this arrangement is detrimental to the trade.

Andrew L. Riker, president of the Locomobile Co., has held several offices in the Chamber. The filing of this motion leaves the suit open to argument at the request of either side.

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N. A. D. A. AGAINST CAR SEIZURE

ST. LOUIS, June 9—At the quarterly meeting of the directors of the N. A. D. A. here Saturday it was decided that the association should lend financial and moral aid in the fight the Georgia State Dealers' Association is making against the law which permits the seizure of a motor car carrying liquor, regardless of mortgage rights of the seller.

The test case has recently been decided adversely to the dealer in the Georgia Court of Appeals. It is planned to carry this case to the United States Supreme Court. The seriousness of this situation is in the fact that the entire country probably will be on a prohibition basis in the near future. A telegram received from the National Automobile Chamber of Commerce assured the N. A. D. A. of full co-operation by that body.

The seizure of these cars, when sold on partial payments, is becoming a considerable factor in the dealers' banking arrangements.

AFRICAN AGRICULTURAL SHOW

JOHANNESBURG, SO. AFRICA, April 23—The Johannesburg Agricultural Show, which is an annual event, closed yesterday with an automobile exhibit disappointing in many respects. The absence of European cars made quite a difference, and the show was not up to its usual standard.

Studebaker's new models were shown for the first time. The Essex made its debut. There were only two tractors at the exhibit, Fordson and the Austin of Birmingham, England. There was no plowing ground satisfactory for the demonstration close at hand but the Fordson gave plowing exhibits nearby.

United States Exports of Cars, Trucks and Parts, by Countries, During April, 1919

Countries	Commercial		Passenger		Parts,
	Number	Value	Number	Value	Value
Belgium	20	$85,122	30	$46,339	$5,194
Denmark	46	79,976	115	169,514	12,924
France	251	1,062,593	4	18,900	290,061
Gibraltar	.....	.....	12	17,718	40
Greece	.....	.....	5	7,890	1,324
Netherlands	8	18,000	42	54,064	120,613
Norway	67	178,611	93	161,483	16,437
Portugal	.....	.....	9	8,590	25,205
Russia in Europe	.....	.....	.....	.....	510
Serbia, Montenegro, etc	1	1,200	.....	.....	.....
Spain	5	10,162	114	90,450	20,213
Sweden	2	3,800	86	102,974	1,000
England	.....	.....	120	158,392	527,087
Ireland	.....	.....	.....	.....	212
British Honduras	.....	.....	2	1,617	719
Canada	168	247,045	1,401	1,224,294	1,582,323
Costa Rica	.....	.....	1	1,436	739
Guatemala	.....	.....	5	7,249	2,163
Honduras	1	800	2	1,052	2,296
Nicaragua	.....	.....	2	2,419	3,644
Panama	20	11,326	15	9,184	15,810
Salvador	.....	.....	10	15,853	2,630
Mexico	72	70,106	304	225,574	61,066
Newfoundland and Labrador	2	2,711	7	10,502	2,530
Barbados	.....	.....	2	1,500	1,096
Jamaica	3	1,521	14	10,405	4,849
Trinidad and Tobago	8	5,160	24	13,383	11,868
Other British West Indies	2	1,100	4	2,450	3,856
Cuba	87	170,169	224	279,538	137,128
Virgin Islands of United States	.....	.....	2	2,425	282
Dutch West Indies	1	600	3	1,450	197
French West Indies	.....	.....	11	7,023	8,078
Haiti	.....	.....	22	25,840	3,230
Dominican Republic	1	3,000	15	9,905	14,253
Argentina	.....	.....	57	61,135	190,823
Bolivia	.....	.....	.....	.....	1,179
Brazil	6	3,765	216	163,095	32,098
Chile	17	28,318	81	157,725	121,388
Colombia	4	4,815	11	8,857	3,591
Ecuador	.....	.....	7	8,922	2,866
British Guiana	6	5,457	5	6,295	3,566
Dutch Guiana	.....	.....	5	2,712	375
French Guiana	1	550	.....	.....	.....
Peru	34	23,990	88	106,329	17,278
Uruguay	18	24,731	293	298,664	72,259
Venezuela	9	4,989	50	40,670	13,765
China	.....	.....	116	120,062	883
Japanese China	.....	.....	.....	.....	15,090
Chosen	.....	.....	.....	.....	88
British India	12	27,886	140	168,464	37,044
Straits Settlements	1	3,250	.....	.....	7,340
Other British East Indies	.....	.....	.....	.....	936
Dutch East Indies	66	129,930	528	659,999	109,020
French East Indies	.....	.....	3	5,490	1,521
Hongkong	1	1,905	1	3,500	1,124
Japan	60	93,974	147	209,295	35,523
Russia in Asia	1	3,800	.....	.....	49,113
Siam	.....	.....	2	2,880	88
Turkey in Asia	.....	.....	1	5,000	.....
Australia	11	18,810	134	133,911	148,552
New Zealand	8	14,516	298	330,223	53,174
Other British Oceania	.....	.....	.....	.....	1,595
French Oceania	.....	.....	.....	.....	767
German Oceania	2	1,335	4	2,365	1,229
Philippine Islands	2	2,492	215	225,615	48,451
British West Africa	3	3,688	19	17,787	3,155
British South Africa	1	844	19	16,883	5,175
British East Africa	.....	.....	13	10,576	1,652
French Africa	1	600	34	28,244	243
Portuguese Africa	.....	.....	.....	.....	66
Egypt	.....	.....	39	19,812	5,644
Total	1,029	$2,352,647	5,226	$5,503,923	$3,866,237
Shipments to:					
Alaska	4	$4,667	2	$1,600	$4,408
Hawaii	10	25,120	136	177,968	29,988
Porto Rico	10	26,126	50	45,520	27,566

This table supplements the one which appeared in the May 29 issue of AUTOMOTIVE INDUSTRIES, *and gives figures for all the individual countries, including those generally grouped under the collective heading of "Other Countries."*

75 Per Cent Detroit Business Improving

In May 69.6 Per Cent Business Normal and Above—31 Per Cent Below

DETROIT, June 10—Approximately 75 per cent of all Detroit business is improving rapidly in volume and earnings. Approximately 19 per cent is stationary while only 6 per cent is on the decline. Figures obtained from representatives of every line of business during May show that 25 per cent of business is above normal; 44 per cent normal, while 31 per cent is below normal but slowly climbing.

Price uncertainty is the greatest obstacle facing manufacturing lines. This is especially noticeable in the metal industries due entirely to the steel situation. Continued advance in the price of all commodities is due to wage increases and is halting development and readjustment more than any other single influence.

Detroit's prosperity is reflected in her banking institutions, 23 of which gained $43,394,906 in total resources between March 4 and May 12. On May 12, banking resources here totaled $517,510,360, as compared with $474,115,454 on May 4. The prediction is that the next statement of Detroit banks will show a total gain in resources of at least $200,000,000. This opinion is based upon the belief that millions of dollars involved in war orders will be settled by that time and that considerbale foreign business is coming.

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BRITISH IMPORT RESTRICTIONS

LONDON, June 9—Recent announcements from the Board of Trade on further relaxation of import restrictions contains some interesting information for American exporters.

Rubber tires are to be admitted at the rate of 50 per cent of the 1913 importations. This is more liberal than the admission of cars, which is based on 50 per cent of 7 months of 1913.

The restrictions on the importation of the following articles are to be removed: Motor car jacks and track jacks, files, bronze castings, (machine or phosphor bronze), foundry flasks, springs for the upholstery trade, friction clutches, flexible metallic tubing, rubber manufactures other than tires, boots and shoes and stationery articles.

The importation of the following articles is to be licensed only exceptionally as and when required: Portable shop cranes, electric hoists and steel pulley blocks, except Yale triplex electric hoists, which are to be rationed to regular pre-war importers at the rate of 100 per cent of 1913 importations, steel tanks, trolleys and trucks for warehouse and wharf, shaft bearings, shaft bearing boxes, blocks for shafting, shaft collars, shaft couplings, shaft hangers, shaft hanger frames, metal baths and fittings thereof, iron and steel welded tubes up to 2 inches in diameter.

The importation of the following articles will be licensed exceptionally as and when required: fire extinguishers, electrical measuring instruments of all kinds, excepting those with 4-in. dials and under.

It is also reported that bulbs for electric lamps will be admitted into Great Britain at the rate of 50 per cent of the 1913 imports, and dry cells and primary batteries, except those for pocket lamps will be admitted at the rate of 20 per cent of the 1916 imports, according to information just received by the War Trade Board.

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Expansion Plans Reflect on Machinery Trade

DETROIT, June 10—Expansion plans of the automotive industry are flooding the Detroit machinery makers and dealers with new business. A situation rather slow and gloomy in February and March has given way to one of optimism in May and June, and every indication now points to more business than many firms will be able to handle.

During the month of May, many automotive concerns announced expansion plans, the results of which reflect directly upon the machinery trade. Some of the companies announcing their plans last month are: Detroit Seamless Steel Tubes Co., new plant, $3,000,000; Saginaw Malleable Co., plant additions, $275,000; Standard Parts Co., Flint, new plant, $350,000; Jordan Motor Car Co., Cleveland, new plant, $250,000; Kenosha Wheel & Axle Co., Kenosha, Wis., new plant, $500,000; General Motors Corp., new plants, equipment, etc., in Michigan alone, $30,000,000; Henry Ford & Son, Dearborn, and in other states, plants and equipment in Michigan and other states, $2,500,000; General Motors Corp., outside of Michigan but within the United States, $12,000,000; in Canada, $6,000,000; Goodyear Tire & Rubber Co., Akron, plant addition, $500,000; Studebaker Corp., South Bend, new appropriation, $4,000,000; Maxwell Motors Corp., for Canadian plant, $1,000,000. In addition at least $2,500,000 has been scheduled for plant additions and new equipment by the firms in Michigan.

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ELCAR INCREASES PRICES

CHICAGO, June 9—The price of the 6-cylinder Elcar has been raised from $1,375 to $1,475. The 4-cylinder remains the same, $1,175.

	New Price	Old Price
6-cylinder	$1,475	$1,375
4-cylinder	1,175	1,175

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CONTINENTAL MOTORS ADDS

MUSKEGON, MICH., June 7—Continental Motors Corp. will spend about half a million or more in making building additions to its local plant and in adding new machinery.

Profit Tax Encourages Building Operations

Money Going into Plant Additions and Improvements to Avoid Heavy Taxes

DETROIT, June 9—The excess profit tax, which is taking from 40 per cent to 75 per cent of the profits of local manufacturers, is the cause of the greatest industrial expansion in the history of the city. Profits spent in expansion, plant improvements, new equipment, etc., are non-taxable, and scores of manufacturers are putting the major portion of their money back into their business. In other words, the government is paying for 60 per cent of expansion projects, here and elsewhere, for if the money was not invested in improvements, etc., most of it would go to the government in taxes.

Increased Capitalization

Dozens of companies have increased their capitalization and have erected new plants. New factories are springing up everywhere. The investment in new plant units, improvements, equipment, etc., will run high into the millions. Many concerns are building homes for their workers. Since Jan. 1 approximately $1,500,000 has been invested monthly in new buildings, not to mention the establishments which have changed hands, involving an equal, if not greater, amount.

The automotive industry has not been slow in grasping every expansion opportunity. In fact, the industry has set the pace for the rest of the manufacturing field. This is shown by the remarkable expansion projects of General Motors and Studebaker corporations.

Since the government fixed the price of steel and that market became more or less steady, as far as the building trades were concerned, construction plans held in leash by scores of big companies were released. Steel prices are in no way checking building work here.

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PACKARD WINS GEAR SUIT

WASHINGTON, June 11—The Packard Motor Car Co. is decleared to be originator of the spiral bevel gear axle in a decision handed down by the Court of Appeals of the District of Columbia, a court of last resort in such actions. The Gleason Works of Rochester, N. Y., was the contender in the suit. The decision rules that a Packard employee was the inventor of the machine and process of making the gears in 1912 and that in 1913 the Gleason works devised a faster machine than that used by the Packard Co.

The decision follows, by a few days, the purchase of the patent rights by the Gleason Works. There are now nearly 400 Gleason machines in operation, each having a capacity of 10,000 spiral bevel gears annually.

Slight Prospect of Trade With Europe is Hanch's Report

(*Continued from page* 1363)

had been the father of high protection, should come to France and tell her what duties she should place on American automobiles.

In defending France's present attitude with regard to automobiles Mr. Cezanne says:

"Concerning the requirements of motor vehicles I should like first of all to state that the French Chambre Syndicale des Constructeurs d'Automobile, having studied this question very seriously for some months, is firmly resolved that future necessary general interests of the country must be considered before the private interests of automobile constructors. This is the policy that has been followed during the whole war.

"I think you have been misinformed as to the extent of the requirements of the French clientele and I should like to give you correct details showing by incontestable figures these requirements are much smaller than the supplies which could be made either immediately by the French military authorities, who hold a very large stock of motor vehicles, or within a relatively short time by our French factories which are able to turn out a much greater number of motor vehicles than are required to supply the French market.

"In 1913 there were 90,959 touring cars in France, of which 48,512 were used for business or professional purposes. To these figures add 6000 trucks which, at that time, were amply sufficient for French requirements. This totals 100,000 vehicles.

France Doubles Trucks Since 1914

"During the war the Government requisitioned all the 6000 trucks and 40,000 touring cars. Due to truck purchases from foreign countries during the war, France has approximately doubled the trucks she had in 1914.

"It may be strange to you that a country like France, with good roads, should have so few touring cars in proportion to its population, one car for every 300 people, whereas the U. S. A. has one car for every 14 people. It is impossible to compare the two situations if we consider the distribution of population per square kilometer and the length of railroad lines in the two countries. The French population is much denser per square mile or kilometer and the railroad mileage per population is greater in France than in the U. S. A.

"From 70 to 75 per cent of the French population belongs to the peasantry living on the land and have not been owners of motor cars.

"Again, in America a motor car lasts 2 or 3 years, whereas in France a car is kept as long as possible by the owner.

"In France the tax is very high and there is little chance for reduction. The luxury tax is 10 per cent for the value of the car and applies to used cars as well. The annual tax on the 15 hp. car ranges from 170 to 500 francs, according to the locality. Gasoline is 5 to 6 times as expensive as in the U. S. A.

"For these reasons, circulation of cars in France cannot develop as rapidly as in the U. S. A. Further handicap exists in consequence of the reduction of private fortunes in France, due to the war, and the great increases that must be made in taxes and, as a result of these conditions, an estimated maximum of 25,000 to 30,000 cars will meet the immediate requirements and that the total number cannot exceed 135,000 cars.

"In 1913 the French factories produced 45,000 to 50,000 car chassis, 25,000 of which were exported. Since then French factories have developed in the manufacture of car material and within a relatively short time will be able to produce 120,000 cars per year in addition to trucks. This is the presumed requirements of the French clientele, which are not all equally urgent and could be made within a year if the French factories were main masters of the French market.

"In addition the French factories are supplemented by 25,000 vehicles which can be immediately released from the army in good condition, and 25,000 others which can be released after undergoing repairs. These alone would meet the most pressing requirements of the French people.

French Factories in Production

"French factories are already beginning to produce cars and production will increase during the next few months so that the French market will reach the saturation point before the end of 1919.

"From the moment the possibilities of French production will have exceeded the requirements of the French market, and if the makers require export trade, will the automobile makers of the U. S. A. be disposed to open the doors of their own market to French cars, which doors they have kept so tightly closed for more than 10 years?

"I, therefore, come to the conclusion that French automobile constructors cannot subscribe to the proposition which you formulate. The manufacturers of the U. S. A. must know that if they were permitted to send large numbers of cars into France, simply because they have been more favored than their French colleagues during the war and are able to make deliveries, that would be dealing a mortal blow to the French manufacturers. This, I feel, is not their intention."

Writing on the subject of future duties on automobiles, Mr. Cezanne continues:

"I quite understand that you find the course even unjust that an American car coming into France to pay a duty of 45 per cent ad valorem, while an Italian car pays only 10 to 15 per cent. Permit me to say with all free candor, that for many years French cars going into the U. S. paid 45 per cent ad valorem while American cars coming into France were only taxed on a basis of 8 to 10 per cent. France found this treatment hard and unjust, the more so because French production could not be a danger for American production, the latter being so much greater.

"At one of the meetings you gave us to understand that there was not much chance of this duty being materially modified and yet, because you have fought beside us, you ask all of the Allies shall be treated on the same footing. It seems to me, and I feel sure that all my countrymen will agree with me, that if any steps are to be taken towards an equitable solution, the government of the United States should take the first step.

"The American automobile industry would be honored in our eyes by bringing the matter to the notice of their government, but it is not surprising that if we cannot have the same tariff for all the Allies, we urge upon the French government at least to apply to each of our Allies the same treatment they think proper to apply to us."

Exports of Automobile Tires from United States During April, 1919

Countries	Value
Belgium	$5,405
Denmark	33,746
France	1,968,453
Greece	3,945
Italy	242
Netherlands	19,120
Norway	30,445
Portugal	3,217
Serbia, Montenegro, etc.	100
Spain	47,392
Sweden	130,942
England	129,623
Bermuda	12
British Honduras	156
Canada	104,658
Costa Rica	503
Guatemala	3,194
Honduras	7,119
Nicaragua	1,415
Panama	16,896
Salvador	18,626
Mexico	75,732
Newfoundland and Labrador	6,352
Barbados	4,003
Jamaica	9,271
Trinidad and Tobago	10,823
Other British West Indies	7,413
Cuba	298,343
Danish West Indies	401
Dutch West Indies	1,652
French West Indies	25,353
Haiti	2,021
Dominican Republic	19,091
Argentina	35,207
Bolivia	448
Brazil	82,187
Chile	149,476
Colombia	6,939
Ecuador	26,996
British Guiana	2,601
Dutch Guiana	390
Peru	25,549
Uruguay	62,373
Venezuela	29,510
China	42,141
Chosen	1,767
British India	101,788
Straits Settlements	63,161
Other British East Indies	4,268
Dutch East Indies	58,339
French East Indies	1,766
Hongkong	5,696
Japan	20,851
Siam	9,766
Turkey in Asia	36
Australia	66,194
New Zealand	59,584
Other British Oceania	4,495
French Oceania	248
German Oceania	464
Philippine Islands	58,667
British West Africa	4,971
British East Africa	7,188
Canary Islands	220
French Africa	285
Egypt	4,701
Total	$3,923,936

McGUIRE CARLISLE SALES HEAD

STAMFORD, CONN., June 10—Clarence V. McGuire has been appointed general sales manager and advertising director of the Carlisle Cord Tire Co. Until now he has been vice-president of Van Patten, Inc., advertising agency. In entering the company he becomes a director of the organization and a member of the executive board.

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Harold W. Woodworth, who has been in the Boston office of the Ahlberg Bearing Co., Chicago, will be in charge of the new office of the company at 511 Westminster Street, Providence, R. I.

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Bruce E. Anderson, formerly with the Ideal Engine Co., has become general manager of the Lansing Body Co., succeeding Frank Thoman, who retires as manager but continues as a member of the board of directors.

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R. S. McLaughlin, president of the McLaughlin Motor Car Co. and a vice-president and director of the General Motors Corp., has been elected president of the newly organized General Motors of Canada, Ltd., which has a capital of $10,000,000.

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L. P. Helm, for two years in charge of production of the Olympian Motors Co., Pontiac, has resigned to become production engineer of the Chief Motors Corp., Port Huron, Mich.

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J. H. McMillan, advertising manager of the Mueller Metals Co., Port Huron, Mich., has resigned, to take effect June 15. His future plans have not been announced.

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Otto Bruenauer, formerly director of sales and engineering of the U. S. Ball Bearing Mfg. Co., Chicago, has resigned. Otto Bruenauer and Howard L. Spohn became identified with the U. S. Ball Bearing company in January, 1917, and with Walter H. Strom had charge of the plant. As a result of reorganization and changes in policy consequent upon the death of Walter H. Strom in January, 1919, Spohn resigned as commercial manager in May, Bruenauer's rssignation following. Spohn immediately returned to the Class Journal Co. Bruenauer's future plans have not been announced.

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CARBURETER HAS NEW MAKER

CHICAGO, June 9—The Beneke & Kropf Mfg. Co. has succeeded the Findeisen & Kropf Mfg. Co. and will make the Rayfield carbureters formerly made by the latter concern. With the reorganization of the company, plans for the material expansion of manufacturing have been formulated. Henry Beneke, formerly vice-president of Hibbard, Spencer Bartlett & Co., has purchased the entire interests of Frederick Findeisen and becomes vice-president and treasurer of the reorganized company. O. F. Kropf remains with the company as active president, and E. A. Bates continues as director of sales and advertising.

Men of the Industry

Changes in Personnel and Position

REQUA RESIGNS AS OIL HEAD

WASHINGTON, June 6—Mark L. Requa resigned to-day as director of the oil division of the U. S. Fuel Administration. Mr. Requa's departure marks the disbanding of the oil division, which controlled the production and consumption of oil, including gasoline, during the war.

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PARKS HEADS MAXWELL

WALKERVILLE, ONT., June 6—George W. Parks has been elected president and general manager of both the Maxwell Motor Co. of Canada, Ltd., and the Chalmers Motor Co., of Canada, Ltd.

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L. E. Lyons, who for the past several months has been acting as sales manager of the B. F. Everitt Co., has resigned to return to the Sheldon Axle & Spring Co., with headquarters in Detroit.

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William F. Jahnke, formerly a member of the city commission of Saginaw, is now connected with the General Motors Corp. in Detroit, being one of six men working out plans for the organization of a savings and investment department of the General Motors Corp.

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UNGER HEADS RESEARCH SOCIETY

DETROIT, June 10—J. S. Unger, with the Detroit branch of the Carnegie Steel Co., was elected president of the Steel Treating Research Society Saturday evening, and L A. Danse, Cadillac Motor Car Co. secretary and treasurer, was chosen vice-president. Dr. John A. Mathews, Syracuse, talked on metallurgical achievements of America during the war and the new alloys devised and new methods invented. He declared that the broken parts of the racing cars which failed to finish in the Indianapolis 500-mile race May 31 should be examined by experts to determine the reason for breakage in order to secure the benefit of this knowledge for future construction.

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TRACTOR SHOWS IN OHIO

COLUMBUS, OHIO, June 10—There will be four tractor shows in Ohio this year. The first will be held here, July 28-29, the second in Piqua, Aug. 1-2, third in Fostoria, Aug. 6-7, and fourth in Akron, Aug. 12-13. The demonstrations will be in charge of Prof. H. C. Ramsower, head of the agricultural engineering department of the Ohio State University.

WHITE PLANS NEW CAR

DETROIT, June 9—D. McCall White, formerly vice-president of the Cadillac Motor Car Co., has opened a temporary office in Detroit. He is actively engaged in getting out the preliminary designs for a new car which he is going to manufacture. The location of the plant in which it will be produced has not been definitely determined.

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DORT MEN IN SOUTH AMERICA

FLINT, June 10—F. A. Petrie, director of sales of the Dort Motor Car Co., for the South American countries, sails on June 20 for Buenos Aires to establish export connections for the Dort car in Latin America. He is taking with him Vaughn Green, engineer and service expert, and four sample cars. He expects to visit Argentina, Uruguay and Chile and will make a careful survey of that field.

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Lynn McNaughton has been appointed general sales manager of the Cadillac Motor Car Co., succeeding Earle C. Howard, who recently resigned. Mr. McNaughton has been with the Cadillac sales organization for 14 years, and assistant under Mr. Howard since 1913.

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B. V. Unwin, until recently connected with the Commonwealth Brass Co., Detroit, has been appointed manager of the sales promotion department of the J. C. Wilson Co., Detroit.

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F. W. McIntyre has been appointed sales manager of the Becker Milling Machine Co., Boston. For the past 16 years he was connected with the Niles-Bement-Pond Co., Boston.

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O. D. Conover, formerly vice-president and chief engineer of the T. W. Price Engineering Co., New York, and production manager of the Ludlum Electric Furnace Corp., has resigned to become sales and production engineer on foundries and steel plants of the Austin Co.

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SHEEPSHEAD BAY ENTRIES

NEW YORK, June 9—A program of four events, 10, 20, 30 and 50-mile race, is scheduled for the Sheepshead speedway June 14. Professional entries include:

Dario Resta	Resta special
Joe Thomas	Mercer special
Louis Chevrolet	Frontenac special
Ira Vail	Hudson special
Denny Hickey	Stickel special
J. M. Reynolds	Frontenac special
Dave Lewis	Meteor special
Tommy Milton	Duesenberg special
Ralph DePalma	Packard special
Rene Thomas	Ballot
Albert Guyot or Louis Wagner	Ballot

The 20-mile event is to be an invitation race for non-professional drivers. The two entries for this event received by the Contest Board of the American Automobile Association so far are:

W. T. Comerford	Stutz
Eddie O'Donnell	Duesenberg

Current News of Factories

Notes of New Plants—Old Ones Enlarged

BRIGGS & STRATTON WILL ENLARGE

MILWAUKEE, WIS., June 9—The Briggs & Stratton Co. will enlarge its productive facilities aproximately 100 per cent at a cost of nearly $500,000. Ground will be broken early this week for a 5-story fireproof factory building, 60 x 185 ft., duplicating the present factory, erected about three years ago. In addition, a new office building, laboratory and engineering building, 69 x 120 ft., 4 stories high, will be built. The new facilities will be available by Oct. 1.

The company also will take over the motor-wheel department of the A. O. Smith Corp., Milwaukee. The motor-wheel is a gas-engine attachment for bicycles. The working force will be enlarged to 1,000 or 1200 in three or four months.

Stephen E. Briggs, president and general manager, left last week for Europe to investigate market conditions for export. During hostilities, the larger part of the company's facilities were devoted to the manufacture of hand and rifle grenades.

ENGLISH COLUMBIA AGENCY

DETROIT, June 6—The Columbia Motors Co., Detroit, has engaged Stanley Watson Inc., London, Eng., to take the agency for the Columbia car abroad.

PERFEX TO DISMISS BANKRUPTCY

MILWAUKEE, WIS., June 9—A petition seeking dismissal of involuntary bankruptcy proceedings filed March 28 against the Perfex Radiator Co., Racine, Wis., has been set for hearing on Wednesday, June 18, by Judge F. A. Geiger of the Federal Court at Milwaukee. The plant has been continued in operation under the direction of Julius J. Goetz, receiver, since proceedings were instituted.

DIVIDENDS DECLARED

The McCord Mfg. Co., Detroit, quarterly dividend, 75 cents, payable July 1 to stockholders of record June 25.

Pierce-Arrow Motor Car Co., Buffalo, quarterly dividend, 2 per cent, payable June 14 to stockholders of record May 31.

CLEVELAND, June 11—The Cleveland Tractor Co. will increase its capitalization $1,980,000. Stockholders will be given first opportunity to subscribe to the new stock. A stock dividend of 10 per cent was also declared, and an initial quarterly dividend of 1½ per cent beginning July 1, thus placing all the Cleveland stock on a 6 per cent basis.

Allis-Chalmers Manufacturing Co., Detroit, regular quarterly dividend, 1¾ per cent on preferred, and ¾ per cent on account of accumulated dividends on preferred, both payable July 15 to stockholders of record June 30.

Stutz Motor Car Co., Indianapolis, regular quarterly dividend, $1.25 a share, payable July 1 to stockholders of record June 23.

INTERNATIONAL HARVESTER BUYS PLOW

CHICAGO, June 9—The International Harvester Co. has purchased the Chattanooga Plow Co., maker of chilled plows. The Chattanooga Plow Co. was formed 40 years ago and is being operated by the founders. Its plant covers about 3½ acres of a 7-acre site. The line of horse and power cane mills established by the Chattanooga company will be continued by the Harvester company.

PLANS FOR 150,000 FORDSONS

DEARBORN, June 6—Henry Ford & Son plans to produce approximately 150,000 tractors during the fiscal year commencing June 1, 1919. The plant has been in operation 14 months and on May 1, the date it closed down for inventory, it had made 53,078 tractors. Inventory work was completed June 1 and the company is back in production. Approximately 100 tractors were run daily this week, and before the middle of June the daily output will be between 300 and 400 machines. Orders have been received from France, England and Belgium for 1000 tractors.

NORTHWAY MAKES 580 ENGINES DAILY

DETROIT, June 6—The Northway Motors Corp., one of the General Motors units, is averaging 580 automobile engines daily. The company is also making engines for the Sampson tractor. Approximately 400 engines are being turned out daily for the Oakland Motor Car Co., 150 for Olds Motor Works and 30 for the Cole Motor Car Co. It will be nearly one year before the building program, recently outlined for this company, goes into effect.

ONEIDA PRODUCTION DOUBLED

GREEN BAY, WIS., June 7—The Oneida Motor Truck Co. since the end of the war has more than doubled its production and increased its sales by 130 per cent. During May salesrooms were established at Baltimore, Denver and Sioux City.

FORD STREET CAR NEXT

DEARBORN, June 6—Within two weeks the first of Henry Ford's "street cars," with which he hopes to solve Detroit's transportation problem, will be in operation. The big gasoline vehicle is nearing completion at the Dearborn tractor plant. C. J. Hall of Los Angeles, Cal., is aiding Mr. Ford in designing and construction work.

MARTIN-PARRY MERGER

INDIANAPOLIS, June 9—The Martin Truck & Body Corp., York, Pa., and the Parry Manufacturing Co. of this city, both commercial car body makers, have merged as the Martin-Parry Corp. John J. Watson, Jr. is chairman of the board, and other directors are: Guy E. Tripp, Westinghouse Electric & Manufacturing Co.; James F. Shaw, Knauth, Nachod & Kuhne; F. M. Small, former president of the Martin Truck Co.; Robert I. Burr, S. C. Parry, Parry Manufacturing Co.; Walter R. Herrick, Herrick, Berg & Co., and George R. Walbridge, Bonbright Co., Inc.

COMPLAINT AGAINST PAN MOTORS

WASHINGTON, June 6—The Federal Trade Commission has issued a complaint against the Pan Motor Co., St. Cloud, Minn., and the president, Samual C. Pandolfo, charging him and the company with having sold stock worth $4,723,111 and deceiving the public by circulating false statements and unfair advertisements regarding the assets and resources of the company. They claim there were 54,000 recorded subscribers of stock of whom 39,000 have paid their subscriptions in full.

The commission complains that the Pan Motor Co. represented that they planned to manufacture passenger automobiles on a large scale but merely assembled 200 cars.

This is the first formal complaint issued by the Federal Trade Commission, and the defendants are ordered to file their answer by July 10.

REO MAKING 50 A DAY

LANSING, MICH., June 7—The Reo Motor Car Co. averaged 30 per cent more cars in May than the average production for the first quarter. The company is producing from 40 to 50 trucks daily.

800,000 KELSEY WHEEL SETS IN 1919

DETROIT, June 7—The Kelsey Wheel Co.'s 1919 output will be 800,000 sets of wheels, as against 690,000 in 1918. In addition to automobile wheels the company is now making automobile bodies and brake bands.

5 HINKLEY ENGINES A DAY

DETROIT, June 6—The Hinkley Motors Corp., after shifting from a 100 per cent war rating to a peace basis, got into production June 1 and is now running approximately 5 engines daily. The company expects to make 6000 engines this year and 15,000 in 1920. About 350 men are employed.

ACASON IN CAPACITY PRODUCTION

DETROIT, June 6—The Acason Truck Co. is producing from 20 to 23 trucks a day, which is plant capacity.

AUTO WHEEL PRODUCTION

LANSING, June 3—The Auto Wheel Co. is now approaching capacity production. The company is producing 450 sets of wheels daily.

Calendar

SHOWS

Aug. 30-Sept. 6—Minnesota. State Fair.

Sept. 1-6 — Indianapolis, Ind. State Fair, Cars and Accessories, Indianapolis Automobile Trade Assn., John B. Orman, Manager.

Sept. 13-20—Cincinnati, O. Ninth Annual, Music Hall, Cincinnati Automobile Dealers' Assn., H. K. Shockley, Manager.

*Oct. 9-19—Paris. Grand Palais, International Automobile Mfrs. Congress.

Nov. 7-16—London. Olympia Motor Car Exhibition—Society of Motor Mfrs. and Trades.

December — Brussels. International Automobile Mfrs. Congress.

Jan. 3-10 — New York, N. Y. Grand Central Palace, National Automobile Chamber of Commerce, S. A. Miles, Manager.

Jan. 24-31—Chicago, Ill. Coliseum, Cars; Drexel Pavilion, Trucks; National Automobile Chamber of Commerce, S. A. Miles, Manager.

January — New York. International Automobile Mfrs. Congress.

February — Chicago. International Automobile Mfrs. Congress.

Feb. 23-Mar. 6 — Birmingham, Eng. British Industries Fair.

TRACTOR SHOWS

June 9-12—Denver, Colo. Sectional Tractor Demonstrations, Denver Tractor Club.

July 14—Wichita, Kan. Automotive Committee of National Implement Assn.

July 28-29—Columbus, O. Tractor show in charge of Prof. H. C. Ramower, head of agricultural engineering department of Ohio State University.

Aug. 1-2 — Piqua, O. Tractor show in charge of Prof. H. C. Ramower, head of agricultural engineering department of Ohio State University.

Aug. 18-22—Aberdeen, S. D. Sectional Tractor Demonstrations.

October—Ottawa, Ont., Can. Interprovincial Plowing Match and Tractor Demonstration.

CONTESTS

June 12-13—Travers Isl., N. Y. Greenfield, Mass., and return. Inter-City reliability run.

†June 14—Sheepshead Bay, L. I. Speedway race.

July 4—Hohokus, N. J. Dirt Track Event.

July 4—Tacoma, Wash. Annual speedway races.

July 4—Atlantic City, N. J.—Airplane races—Aeronautic Convention.

*July 5—Cincinnati, O. Speedway.

*July 19—Uniontown, Pa. Speedway race.

*July 26—Sheepshead Bay, L. I. Speedway race.

*Aug. 15 — Middletown, N. Y. Dirt track event.

*Aug. 22-23—Elgin, Ill. Road race.

*Aug. 23—Sheepshead Bay, L. I. Speedway race.

*Sept. 1—Uniontown, Pa. Speedway race.

*Sept. 20—Sheepshead Bay, L. I. Speedway race.

*Sept. 27—Allentown, Pa. Dirt track event.

*Oct. 1—Cincinnati, O. Speedway race.

*Oct. 4—Trenton, N. J. Dirt track event.

*Oct. 11—Danbury, Conn. Dirt track event.

*Tentative dates.
†Sanctioned.

CONVENTIONS

June 12-14—Pittsburgh. Annual convention of American Drop Forge Assn. and Drop Forge Supply Assn., William Penn Hotel.

June 16-19—Detroit. American Society of Mechanical Engineers spring meeting, Hotel Statler.

June 23-28—Ottawa Beach, Mich. S. A. E. Mid-summer Meeting.

July 9-10—Buffalo. Motor and Accessory Mfrs. Assn. Mid-summer convention.

Sept. 22-24—Philadelphia. Annual Convention, National Association of Purchasing Agents. Bellevue - Stratford.

May 12-15, 1920—San Francisco. Seventh National Foreign Trade Convention.

January — Washington. Pan-American conference.

STROMBERG FINANCIAL REPORT

NEW YORK, June 9—The Stromberg Carbureter Co. of America, Inc., holding company of the Stromberg Motor Devices Co., has just published its annual report for the fiscal year ending Dec. 31 last. Net profits of $279,097 are shown, as compared with $318,819 of the previous year. The profit per share is $5.58, as compared with $6.37 in 1917, on the 50,000 shares of no par value.

The income of the Carbureter company consisted of $350,628, the net earnings of the Motor Devices company and $21,742 other income, a total of $372,368. The deductions are $70,392 for Federal taxes and $22,879 for other taxes and sundry expenses. In this report no provision is made for the 1919 taxes because the Federal rate was not known at the time the books were closed.

The Motor Devices Co. report shows sales for the year of $2,160,373 and operating profit of $384,781. The added income was $6,817, making total income $391,598. Charges of $40,972 were deducted for taxes, etc. The Carbureter company balance sheet shows:

Assets.

Investment Stromberg Motor Devices Co.	$1,180,761
Cash	38,211
Liberty bonds	25,000
Notes receivable and accrued interest	201,400
Furniture and fixtures	238
Total	$1,445,610

Liabilities.

Capital stock (50 000 shares without par value)	$250,000
Surplus	1,195,610
Total	$1,445,610

CARS AND TRUCKS FOR ARGENTINA

WASHINGTON, June 10—An additional field for motor cars and trucks has been opened in a section of Argentina as a result of the construction of a macadamized highway connecting the cities of La Plata and Bahia Blanca, which traverses the distance of Lomas de Zamora, Can · Vicente, Canuelas, Monte, Las Flores, Azul, Olavarria, Laprida, Pringles and Tornquist. The first section of this road has been completed. La Plata is also connected directly with Buenos Aires by a macadamized highway. The new road, nearly 500 miles long, will link all of the border section with the ports.

TRADE-MARK LAW

WASHINGTON, June 11—A new trade-mark law in Honduras, effective Aug. 1, 1919, provides for a registration fee of $50 gold for each trade-mark. This increased fee will not apply to applications filed before Aug. 1.

JAPANESE REGULATIONS

WASHINGTON, June 6—New automobile regulations have been promulgated by Japan. Chauffeurs, who are required to be 18 years old, are divided into two classes, A and B, according to their qualifications as operators.

Those in class A may operate any kind of car and their licenses are good for five years. Chauffeurs in class B can also operate for five years on the same license, but only special cars or classes of cars.

The speed limits vary according to the width of the streets. On roads between 12 and 18 ft. wide, machines may run at the rate of 8 m.p.h., between 18 and 36 ft. at 12 m.p.h., on roads above 36 ft. in width at 16 m.p h. Within the city limits machines must not travel on streets less than 18 ft. wide. They may run at a speed of 12 m.p.h. on streets between 18 and 36 ft. wide and on those wider than 36 ft. 16 m.p.h. is the limit.

FOREIGN TRADE OPPORTUNITIES

WASHINGTON, June 10—The Bureau of Foreign and Domestic Commerce, Department of Commerce, has received requests for automobile or parts and accessories agencies of business from individuals and companies in foreign countries. These are listed below. For further information address the Bureau of Foreign and Domestic Commerce, Room 149, Customhouse, New York, specifying each Foreign Trade Opportunity number on a separate sheet of paper.

Mexico—Cars, motor trucks and accessories. No. 29 504.

Philippines—Cars and tires. No. 29,217.

Australia—Accessories and pressed steel grease cups. No. 29,524.

Belgium—For 3 firms sale of trucks, with trailers, 1½ to 3 tons, small agricultural machinery, tires, solid and pneumatic. No. 29272.

Belgium—Small cars, trailers, trucks and motorcycles. No. 29274.

Switzerland—Engines, trucks, tractors. Correspondence may be in English. No. 29280.

Catalogs with price lists of medium and high grade cars. Correspondence may be in English. No. 29313.

Spain—Cars. No. 29331.

LITHUANIA MARKET FOR CARS

NEW YORK, June 7—Lithuania, which has been freed from all export restrictions by the War Trade Board, offers a new field for American cars. It is a rich agricultural country organized into co-operative enterprises, which make it possible for her to buy on a large scale, according to a bulletin distributed by the New York office of the Lithuanian National Council. It is in need of proper motor equipment, including trucks, tractors and cars, offering a new market to the American manufacturer.

SHIP TO GERMAN AUSTRIA

WASHINGTON, June 9—Applications will now be considered by the War Trade Board for exportation of automotive products to German Austria.